Issue 2

Du Mont
Cathode-ray Oscillograph

TYPE 274-A

OPERATING AND MAINTENANCE MANUAL

Allen B. Du Mont Laboratories, Inc.
CLIFTON, NEW JERSEY

Obviously, the design of any piece of electrical indicating equipment results from a series of compromises which represent the designer's opinion of an ideal instrument consistent with contemporary engineering techniques and present-day production possibilities.

In developing this instrument, an attempt has been made to incorporate circuits the characteristics of which, we believe, will satisfy the greatest number of applications, and to this end many circuit combinations have been included to extend its flexibility and versatility.

We feel, however, that the real test of any instrument is the opinion of the man who uses it. This day-to-day test of the instrument's advantages and limitations will prove, more than any other method, just what characteristics are desirable, why the range of any given component or function of the equipment should be extended, and how important such modification is.

Because of the nature of the equipment manufactured by Allen B. Du Mont Laboratories, Inc., it is only by complete cooperation between the customer and our Engineering Department that satisfactory designs can be achieved. In an attempt to continually extend the applicability of our equipment to the problems of the engineer, we sincerely request suggestions advising in what manner the design of this equipment may be further extended to include these problems.

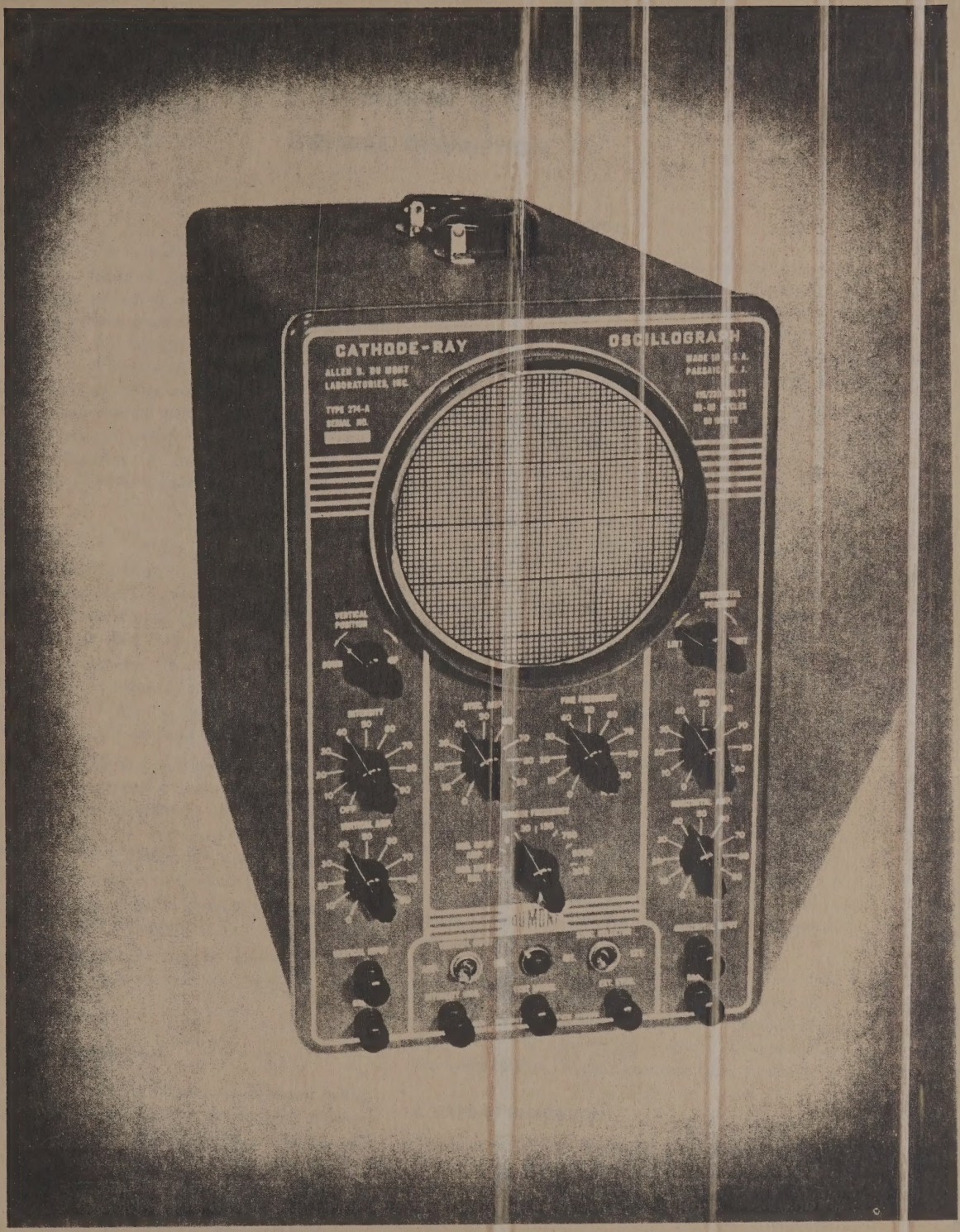

FIGURE 1-1
DU MONT TYPE 274-A CATHODE-RAY OSCILLOGRAPH

SECTION I

GENERAL DESCRIPTION

1. PURPOSE

The Type 274-A Cathode-ray Oscillograph is designed primarily for analysis of electrical circuits by a study of the wave forms of voltage and current at various points. As a general purpose instrument, however, it may be employed to study any variable, within the limits of its frequency response characteristics, which can be converted into electrical potentials. This conversion is made possible by the use of some type of transducer, such as a vibration pickup unit, pressure pickup unit, photo cell, microphone, or a variable impedance, which may be a carbon pile, variable inductance or variable capacitor.

2. CIRCUITS

a. In a specific problem the unknown quantity (which is usually plotted along the vertical or Y-Axis) is a function of some known quantity, such as time, measured along the horizontal or X-Axis. Circuits are incorporated in this insrument which generate a sawtooth-shaped voltage wave to be used as a time-base. This time-base is applied to the horizontal or X-Axis, so that the unknown quantity may be plotted as a linear function of time.

b. Provision is made so the intensity of the trace may be modulated. A terminal is provided on the front panel which is capacitively coupled to the control grid of the cathode-ray tube for the introduction of an external signal. Positive pulses applied to this terminal will intensify the trace at time intervals corresponding with the intervals between pulses. Negative pulses of approximately 15 peak volts will blank the beam.

c. A self-contained power supply furnishes the various voltages and currents for complete operation of the instrument.

3. PHYSICAL DESCRIPTION

Type 274-A Cathode-ray Oscillograph is shown in Figure 1-1. It is enclosed in a gray metal cabinet provided with a plastic carrying handle attached to the top. All controls necessary for the operation of the instrument are located on the front panel. A removable calibrated scale, Type 216-C, for making relative and quantitative measurements is mounted on the face of the cathode-ray tube.

4. FREQUENCY RANGE

a. TRANSIT TIME.—The cathode-ray tube is essentially an indicating device with a pointer of negligible inertia. For this reason its only frequency limitation occurs at deflection frequencies where the transit time of the electron beam across the face of the deflection plates must be considered. Since the electron velocity through the deflection plate space has a finite value, it is possible to apply a deflecting potential which reverses in polarity during the transit time of the electrons.

For example: assume that a 1,000 mc sine wave is applied to the vertical deflection plates. The period of one cycle will be .001 μs. Assume further that the transit time of the electron beam across the face of the deflection plates is .001 μs. The beam will then react to equal positive and negative deflection forces as it travels across the face of the plates, with a resulting deflection of zero. In the modern cathode-ray tube, this effect is not apparent at frequencies below 100 megacycles per second and may normally be disregarded at the lower frequencies.

b. AMPLIFIERS.—The above frequency limitations apply when the cathode-ray tube beam is deflected directly from the signal source without employing any type of vacuum tube amplifier. Since potentials ranging from one hundred to one thousand volts may often be required for full scale deflection of a cathode-ray tube, amplifiers have been incorporated in this instrument to increase the sensitivity of the device so that it may give usable indications from relatively low potential sources. The frequency response of the amplifiers must be considered in the application of this instrument to any problem.

The amplifiers incorporated in the Type 274-A have been designed to give uniform response within 40% over a frequency range from 20 to 200,000 sinusoidal cycles per second. The complete characteristics of the amplifiers are summarized in the quick reference table, Table 1-1.

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TABLE I-I

QUICK REFERENCE DATA

CATHODE-RAY TUBE

Type	5BP-A
Accelerating Potential	1200 volts

VERTICAL AXIS

Deflection Factor	
Direct	16 rms volts/inch ±17%
Full Gain	0.20 rms volts/inch (max.)
Sinusoidal Frequency Response (full gain)—Uniform within 40% from 20 cps to 200 kc.	
Maximum Input Potential	400 rms volts or 600 d-c volts or 600 volts peak
Input Impedance	
Direct	4.7 meg; 50 μμf
Amplifier	1 meg; 40 μμf

HORIZONTAL AXIS

Deflection Factor	
Direct	18 rms volts/inch ±17%
Full Gain	0.25 rms volts/inch (max.)
Sinusoidal Frequency Response (full gain)—Uniform within 40% from 20 cps to 200 kc.	
Maximum Input Potential	400 rms volts or 600 d-c volts or 600 volts peak
Input Impedance	
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Amplifier	1 meg; 40 μμf

LINEAR TIME BASE

Gas Triode	Type 884
Sweep Frequency Range	8 cps to 30 kc.

INTENSITY-MODULATION CIRCUIT

Input Impedance	0.47 megohm, 45 μμf
Sensitivity	10 rms volts to blank
Test Signal—A test-signal terminal is provided to furnish a test signal of 6.3 volts at the power-line frequency.	
Positioning	more than 5 inches

POWER SUPPLY

Primary-Power Potential	115 or 230 rms volts ±10%
Frequency	50-60 cycles
Power Consumption	50 watts approx.
Fuse Protection	One ampere

TUBE COMPLEMENT

2—6AC7 Amplifiers
1—884 Sweep Generator
2—80 Rectifiers
1—5BP-A Cathode-ray Tube 5BP1A

PHYSICAL SPECIFICATIONS

Height	14"
Width	8⅝"
Depth	19⅜"
Weight	35 lbs.

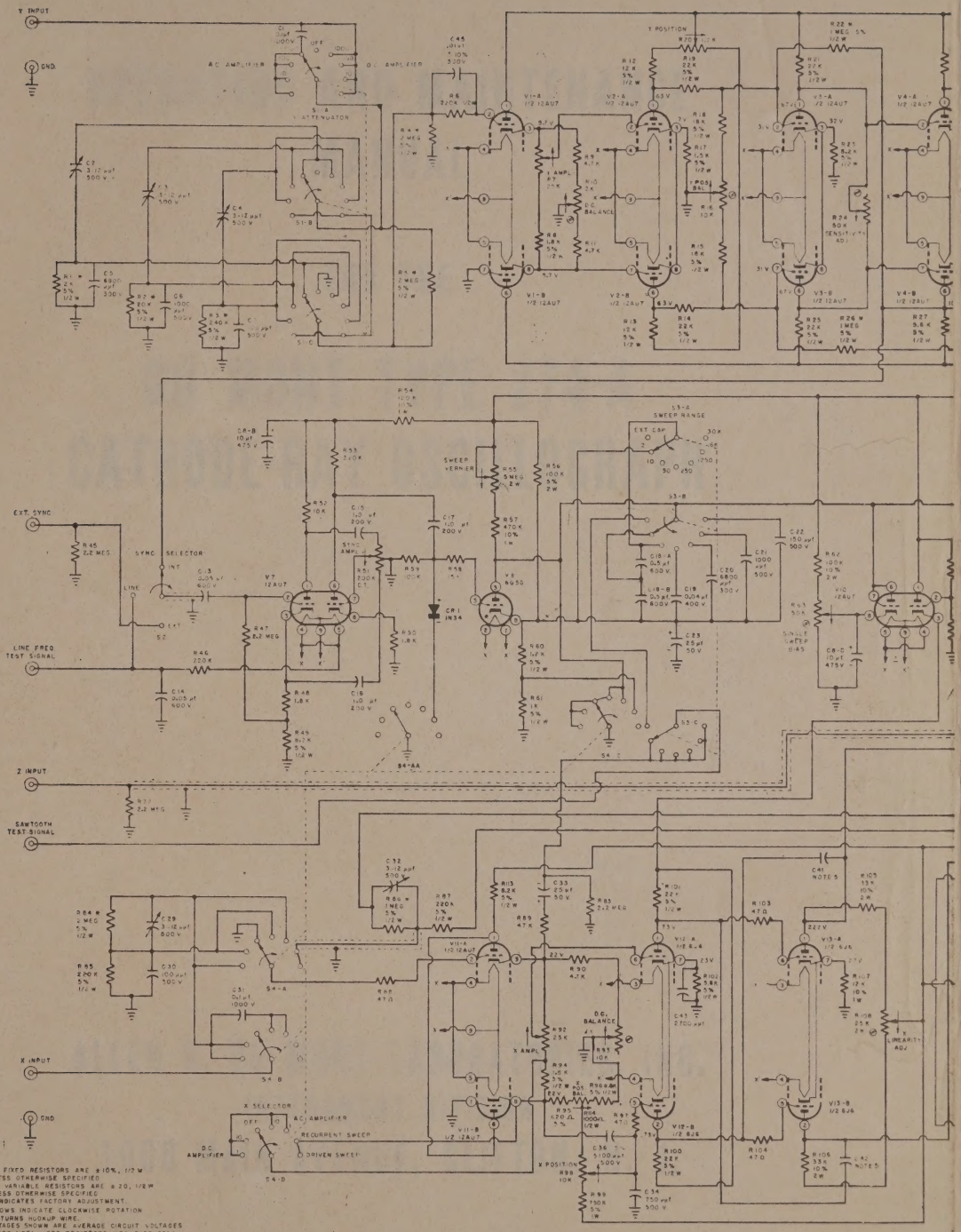
phenomenon which is being studied. The cathode-ray oscillograph is not designed for use as a corrective instrument, which, in itself, performs a specific operation on an electrical signal or on its source. It should rather be considered as an auxiliary instrument which indicates visually the essential characteristics of a signal, thus enabling the operator to quickly make a check on correct functioning or to isolate the causes of any malfunctioning of equipment.

b. INTERPRETATION.—One of the most important procedures used by the oscillograph operator, and the one which probably gives the most trouble to personnel inexperienced in oscillograph work, is the proper interpretation of the patterns traced on the screen of the cathode-ray tube. When interpreting the pattern obtained on the screen of the cathode-ray tube, it should be borne in mind that the unknown signal is always plotted as a function of some signal whose characteristics are known. If the characteristics of the signal on one axis are not known, it will be almost impossible to identify the characteristics of the signal under investigation on the other axis. For this reason it is generally common practice to use for the horizontal variable a sinusoidal signal of known frequency, or a sawtooth signal which has been synchronized to the same or some integral sub-multiple of the frequency of the unknown signal. The sinusoidal signal is often used in applications such as phase, frequency and rate determination. The sawtooth signal gives horizontal deflection which is linearly proportional to time, and it therefore gives a plot of the waveshape of the unknown signal versus time.

c. APPLICATIONS.—The information which may be gained from analyzing screen patterns in the above manner is of great value in determining the characteristics of a device which is under study. The path of a known signal through an amplifier may be followed, and the gain and distortion characteristics of the amplifier may be quickly and easily determined, as well as the point at which the circuit may be faulty. By use of the linear time base as the known function, an unknown waveform may be plotted and analyzed, or the dynamic characteristics of an unknown circuit may be studied. The waveform of a signal shown plotted as a function of the linear sawtooth sweep, will give indications showing the presence of undesirable harmonics, parasitic oscillations, or indication of the degree of faithfulness with which a device is following a desired cycle of operation.

A familiar case of operation where a sinusoidal standard signal is employed for horizontal deflection is found in the application of the cathode-ray tube for frequency comparison of two signals. The unknown signal is fed into the vertical input and the known signal standard frequency is fed into the horizontal input. In this way, the frequency of the unknown signal may be measured by the correct interpretation of the resulting Lissajous pattern.

Another common practice is to impress a modulated carrier upon the vertical input, and the modulation voltage on the horizontal. This results in the pattern known as the modulation trapezoid pattern for the purpose of studying percentage modulation.



NOTES:
1. ALL FIXED RESISTORS ARE ±10%, 1/2 W UNLESS OTHERWISE SPECIFIED.
2. ALL VARIABLE RESISTORS ARE ± 20, 1/2 W UNLESS OTHERWISE SPECIFIED.
3. Ⓐ INDICATES FACTORY ADJUSTMENT.
4. ARROWS INDICATE CLOCKWISE ROTATION.
5. 3-5 TURNS HOOKUP WIRE.
6. VOLTAGES SHOWN ARE AVERAGE CIRCUIT VOLTAGES.
7. (IN) ARE METALLIZED RESISTORS (IRC TYPE BTS).
8. FOR 230V. OPERATION USE 3/4 AMP FUSE.

SCHEMATIC OF CIRCUIT OF
CATHOD
Ref. D

OPERATING AND MAINTENANCE MANUAL

FOR THE

DU MONT TYPE 274-A CATHODE-RAY OSCILLOGRAPH

ALLEN B. DU MONT LABORATORIES, INC.
INSTRUMENT DIVISION
1000 MAIN AVENUE, CLIFTON, N. J.

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ALLEN B. DU MONT LABORATORIES, INC.
INSTRUMENT DIVISION
Clifton, N. J.
U.S.A.

NOTICE

Although this Manual is written for the Type 274-A Cathode-ray Oscillograph, it also applies in general to the Type 274. Circuit schematics for both Types are included inside the back cover.

Part No. 67002891
Issue 2

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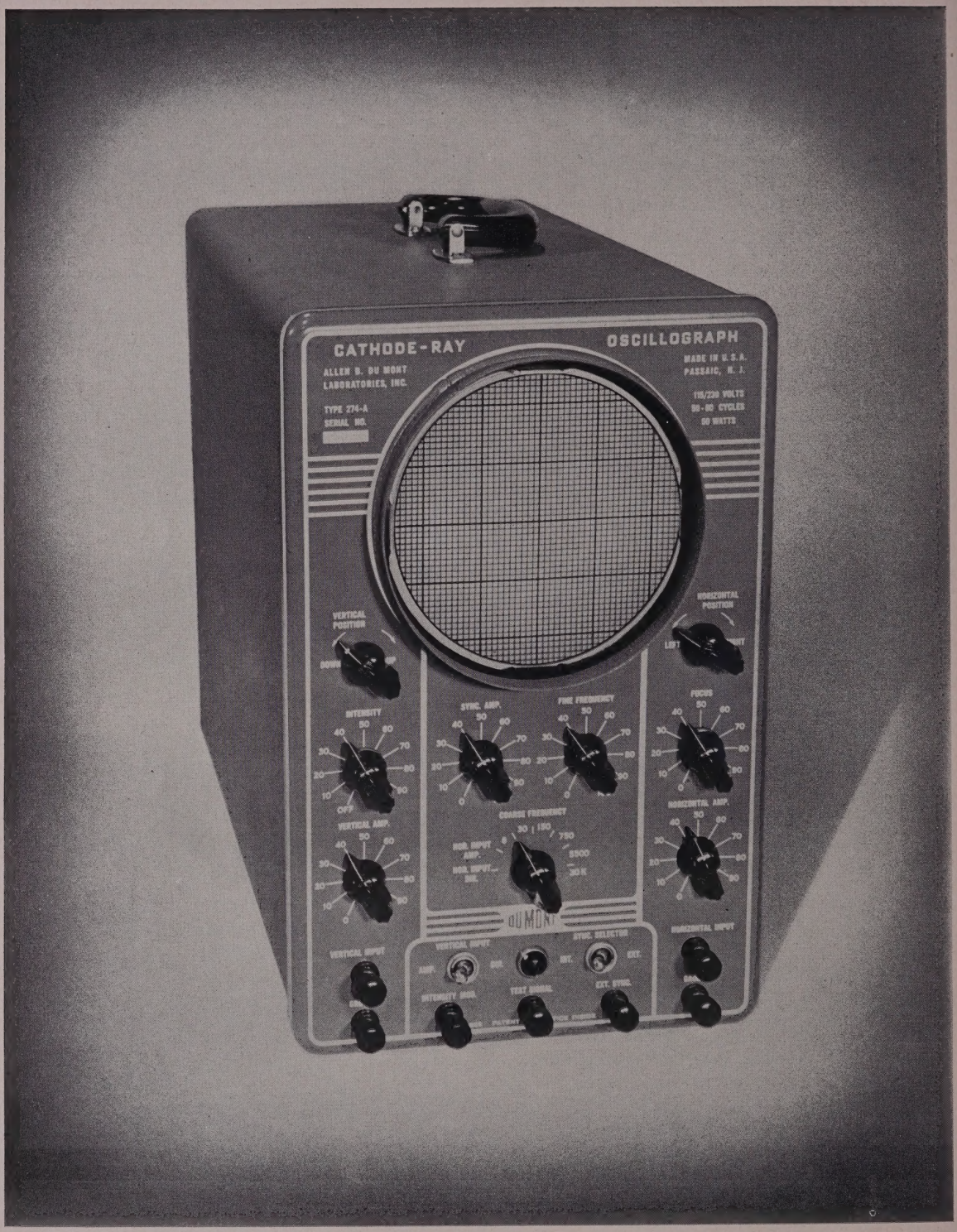

FIGURE 1-1
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4. FREQUENCY RANGE

a. TRANSIT TIME.—The cathode-ray tube is essentially an indicating device with a pointer of negligible inertia. For this reason its only frequency limitation occurs at deflection frequencies where the transit time of the electron beam across the face of the deflection plates must be considered. Since the electron velocity through the deflection plate space has a finite value, it is possible to apply a deflecting potential which reverses in polarity during the transit time of the electrons.

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- Deflection Factor
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- Test Signal—A test-signal terminal is provided to furnish a test signal of 6.3 volts at the power-line frequency.
- Positioning ..... more than 5 inches

POWER SUPPLY
- Primary-Power Potential ..... 115 or 230 rms volts ±10%
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- Fuse Protection ..... One ampere

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PHYSICAL SPECIFICATIONS
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Another common practice is to impress a modulated carrier upon the vertical input, and the modulation voltage on the horizontal. This results in the pattern known as the modulation trapezoid pattern for the purpose of studying percentage modulation.

SECTION II

THEORY OF OPERATION

1. THE CATHODE-RAY TUBE

a. FUNCTION.—As an indicating instrument the cathode-ray tube may be compared to the galvanometer, with the electron beam which is projected from the hot cathode analogous to the galvanometer needle. However, the cathode-ray or electron beam has great advantages over the needle in that it is practically without weight and therefore possesses a minimum of inertia, which makes for infinitely greater flexibility in operation. The beam requires negligible power for deflection so that accurate readings are obtained without loading the circuit under test. The beam can be moved vertically or horizontally or the vertical and horizontal movements may be combined to produce composite patterns on the tube screen. Thus the block diagram, Figure 2-1, shows the cathode-ray tube as the recipient of signals from both the vertical and horizontal amplifiers.

b. OPERATION.

(1) Figure 2-2 shows the internal details of the cathode-ray tube. Electrons emitted from the cathode flow through the control grid toward anodes 1 and 2, are accelerated by the high positive potentials on these anodes. The stream continues between two sets of deflecting plates, horizontal and vertical, and strikes the screen, which fluoresces at the point of impact. With no potential applied to the deflecting plates the cathode-ray beam will appear as a bright spot on the center of the tube screen. If a positive voltage is placed on the right horizontal plate, the beam, and thus the spot, will move to the right in proportion to the potential applied. Because the beam is a stream of electrons (negative electrical charges), it is electrostatically attracted toward an oppositely charged plate. If a negative charge is applied to the same plate, the spot will travel to the left, due to electrostatic repulsion between like charges.

(2) In the Type 274-A Cathode-ray Oscillograph one of each of the pairs of deflection plates is connected to ground so that deflection voltages are applied to only one plate of each pair.

(3) An a-c voltage applied to the horizontal deflection plate will, therefore, cause the spot to move alternately to one side and then the other. This motion will be continuously repeated until the voltage is removed. The visual indication, except at very low frequencies, will appear to be a straight line, due to the effect of persistence of vision (see paragraph c).

(4) Vertical deflection is obtained in precisely the same way when the voltage is applied to the vertical plates.

(5) As a general rule the deflections representing amplitude are produced by applying voltage to the vertical deflection plate, and the pattern resulting from these deflections is said to be along the Y-Axis.

(6) Deflections representing time are usually produced by applying a voltage to the horizontal deflection plate. The patterns resulting from these deflections are said to be along the X-Axis.

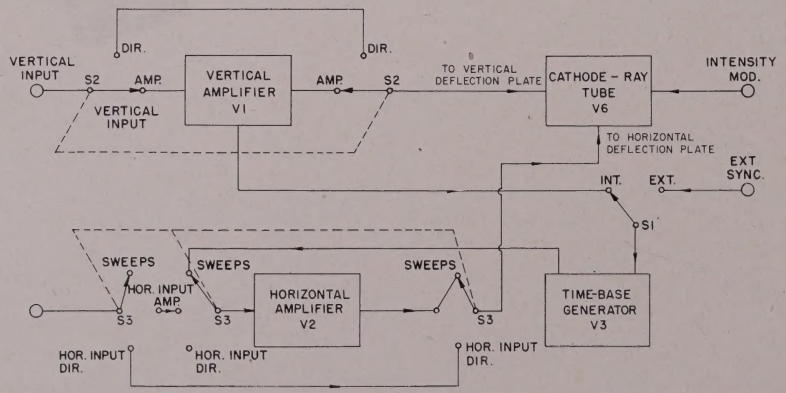


FIGURE 2-1

BLOCK DIAGRAM, TYPE 274-A CATHODE-RAY OSCILLOGRAPH

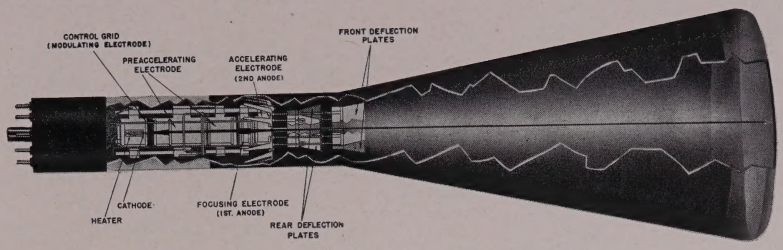


FIGURE 2-2

INTERNAL CONSTRUCTION OF A TYPICAL CATHODE-RAY TUBE

(7) Another operation which may be performed upon the spot or trace is intensity modulation. In this application a voltage is applied to the grid of the cathode-ray tube and its variations modulate the emitted beam. This causes the spot or trace to become brighter or dimmer in accordance with the polarity of these variations. This principle is used to provide timing demarcations or reference points on the trace or pattern. These timing marks may be provided by an external source, the frequency of which is known. Intensity modulation is said to be performed on the Z-Axis of the cathode-ray tube. A further use of this grid connection is to intensify the beam over portions of the trace where the writing rate of the spot is so rapid that the fluorescent screen is not sufficiently excited. Thus the intensity may be made more uniform throughout the entire trace. This feature particularly facilitates photographic recording of the patterns formed. It should be emphasized that the screen excitation (and therefore the pattern intensity) is a function of the beam current and the writing rate. The intensity of the spot at any instant regardless of its position on the screen may be controlled by a variation of this control grid (modulating electrode) bias.

c. PERSISTENCE OF VISION.—Any image reaching the retina of the eye registers and persists there for an appreciable period of time even though the object producing the image disappears almost at once from the field of vision. If an intermittently appearing image is reregistered at the rate of 16 or more times per second the image will appear continuous. As an example, "moving" pictures are really a series of "still" pictures projected successively at the rate of 16 or more per second. Similarly, if a cathode-ray spot is moved back and forth over the same path on the screen at the rate of 16 or more cycles per second, the movement or trace will appear to be continuous due to this persistence of vision.

d. CIRCUIT.—A 5BP-A cathode-ray tube is used in this instrument. As shown in the simplified schematic, Figure 2-3, the necessary potentials for operating this tube are obtained from a voltage divider made up of resistors R21 through R26 inclusive. The intensity of the beam is adjusted by moving the contact on R21. This adjusts the potential on the cathode more or less negative with respect to the grid which is operated at the full negative voltage —1200V. Focusing to the desired sharpness is accomplished by adjusting the contact on R23 to provide the correct potential for anode No. 1. Interdependency between the focus and the intensity controls is inherent in all electrostatically focused cathode-ray tubes. In short, there is an optimum setting of the focus control for every setting of the intensity control. The second anode of the Type 5BP-A is operated at ground potential in this instrument. Also one of each pair of deflection plates is also operated at ground potential.

The cathode is operated at a high negative potential (approximately 1200 volts) so that the total overall accelerating voltage of this tube is regarded as 1200 volts since the second anode is operated at ground potential. The vertical and horizontal positioning controls which are connected to their respective deflection plates are capable of supplying either a positive or negative d-c potential to the deflection plates. This permits the spot to be positioned at any desired place on the entire screen.

2. VERTICAL AMPLIFIER

a. INPUT.—The incoming signal which is to be examined is applied to the terminals marked Vertical Input and Ground. These terminals are connected through capacitor C1 so that the a-c component of the signal appears across the vertical amplifier gain control potentiometer R1. Thus the magnitude of the incoming signal may be controlled to give the desired deflection on the screen of the

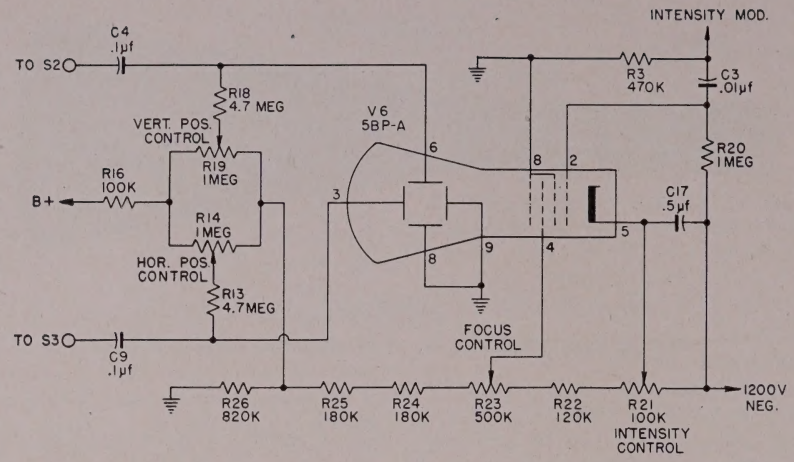


FIGURE 2-3

SCHEMATIC OF CATHODE-RAY TUBE CIRCUITS

cathode-ray tube. Also, as shown in Figure 2-1, S2 has been made available to by-pass the vertical amplifier and capacitively couple the signal from the input terminal to the vertical deflection plate if it is so desired.

b. AMPLIFIER.—In the schematic, Figure 2-4, V1 is a 6AC7 pentode vacuum tube used as the vertical amplifier. As the signal variations appear on the grid of V1, variations in the plate current flowing through V1 will take place. Thus signal variations will appear in opposite phase and greatly amplified across the plate load resistor R7. The capacitor C2 has been added across resistor R2 in the cathode circuit of the tube to flatten the frequency response of this amplifier at the high frequency end. This capacitor because of its low value serves very little use as a cathode by-pass at low frequencies but operates more effectively as the frequency of the signal increases.

c. OUTPUT.—The signal applied to the grid of V1 has been amplified by V1 and is now applied through the second half of S2 and capacitor C4 to the free vertical deflection plate of the cathode-ray tube.

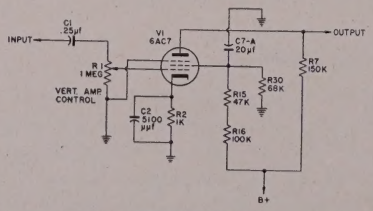


FIGURE 2-4

AMPLIFIER SCHEMATIC

3. HORIZONTAL AMPLIFIER

The horizontal amplifier circuit and the circuit of the vertical amplifier, described in the paragraph above, are identical. A switch in the input circuit makes provision for the input from the Horizontal Input terminals to be capacitively coupled to the grid of the horizontal amplifier or to the free horizontal deflection plate thus by-passing the amplifier, or for the output of the sweep generator to be capacitively coupled to the amplifier, Figure 2-1.

4. TIME BASE GENERATOR

a. GENERAL.

Investigation of electrical wave forms by the use of the cathode-ray tube frequently requires that some means be available to determine the variation in these wave form amplitudes with respect to time. When such a time base is used, the patterns presented on the cathode-ray tube screen show the variation in amplitude of the input signal with respect to time. Such an arrangement is made possible by the use of the time base generator. In operation it moves the spot across the screen at a constant rate from left to right between selected points, returns the spot almost instantaneously to its original position, and repeats the procedure. This is accomplished by the voltage output of the sweep generator. The rate at which this voltage repeats the cycle of sweeping the spot across the screen is referred to as the sweep frequency. The sweep voltage necessary to produce the motion described above must be of a sawtooth wave form such as that shown in Figure 2-5.

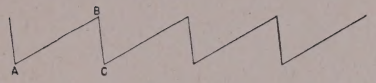


FIGURE 2-5
SAWTOOTH WAVE FORM

The sweep occurs as the voltage varies from A to B, and the return trace, as the voltage varies from B to C. If AB is a straight line, the sweep generated by this voltage will be linear.

However, it should be realized that the sawtooth sweep signal is only used to plot variations in the vertical axis signal with respect to time. Specialized studies have made use of signals of various shapes which are introduced from an external source through the Horizontal Input terminals.

b. CIRCUIT.—The sawtooth voltage necessary to obtain the proper sweep is generated by means of the electronic circuit shown in Figure 2-6, which operates as follows: The gas triode used for this purpose is the Type 884 (V3). The heater heats the cathode which emits electrons as in the ordinary heater type triode. This tube contains an inert gas which ionizes when the voltage between the cathode and the plate reaches a certain value. The voltage at which breakdown will occur depends upon the bias voltage which is determined by the voltage divider resistors R12 and R17. With a specific negative bias applied to the tube in this way, the tube will fire at a specific plate voltage.

Capacitors C10 to C14 are selectively connected in parallel with this tube. Resistor R11 is added to limit the peak current drain by the gas triode. The plate voltage on this tube is obtained through resistors R28, R27, and R11. The voltage applied to the plate of V3 cannot reach the power supply voltage because of the charging affect this voltage has upon the capacitor which is connected across the tube. This capacitor charges until the plate voltage becomes high enough to ionize the gas in the tube. At this time, the tube starts to conduct and the capacitor discharges through the tube until its voltage falls to the extinction potential of the tube. When the tube stops conducting, the capacitor voltage builds up until the tube fires again. As this action continues, it results in the sawtooth wave form of Figure 2-5 appearing at the junction of R11 and R27.

c. SYNCHRONIZATION.

(1) Provision has been made so the sweep generator may be synchronized from the vertical amplifier or from an external source. The switch, S1, shown in Figure 2-6, is mounted on the front panel to be easily accessible to the operator.

(2) If no synchronizing voltage is applied, the discharge tube will begin to conduct when the plate potential reaches the value of E_f (Firing Potential). When this breakdown takes place and the tube begins to conduct, the capacitor is discharged very rapidly through the tube, and the plate voltage decreases until it reaches the extinction potential E_x. At this point conduction ceases, and the plate potential rises slowly as the capacitor begins to charge through R27 and R28. The plate potential will again reach a point of conduction and the circuit will start a new cycle. The rapidity of the plate voltage rise is dependent upon the circuit constants R27, R28, and the capacitor selected, C10-C14, as well as the supply voltage E_b. The exact relationship is given by:

$$E_c = E_b\left(1 - e^{\frac{-t}{rc}}\right)$$

Where E_c=Capacitor voltage at time t

E_b=Supply voltage (B+ supply—cathode bias)

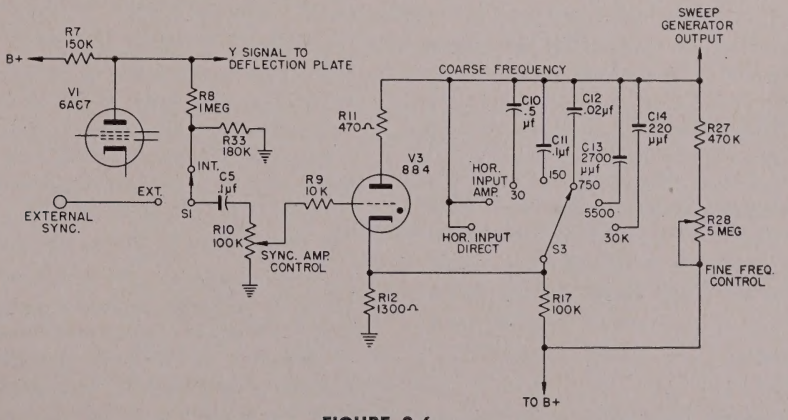


FIGURE 2-6
SCHEMATIC OF SWEEP GENERATOR

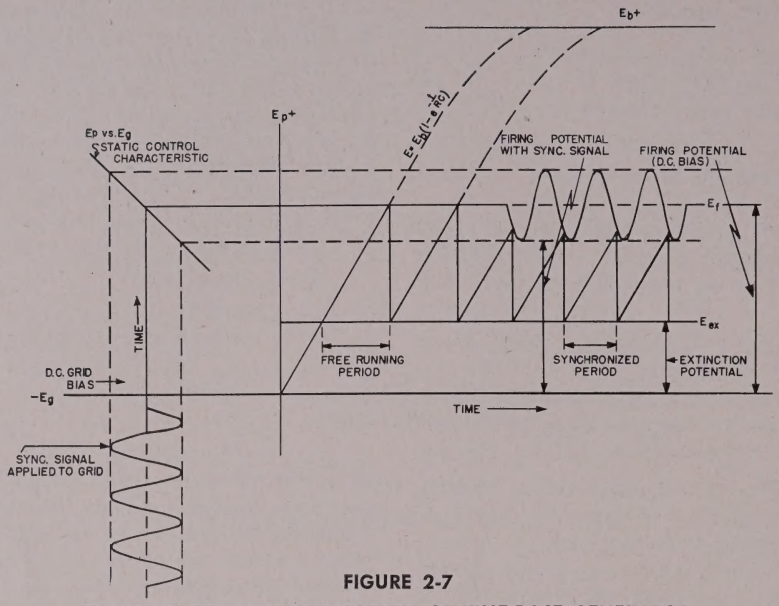


FIGURE 2-7

ANALYSIS OF SYNCHRONIZATION OF TIME-BASE GENERATOR

E_f=Firing potential or potential at which time-base gas triode fires

E_x=Extinction potential or potential at which time-base gas triode ceases to conduct

e=Base of natural logarithms

t=Time in seconds

r=Resistance in ohms (R27 + R28)

c=Capacity in farads (C10, 11, 12 13, or 14)

The frequency of oscillation will be approximately:

$$f = \frac{E_b}{rc}\left(\frac{1}{E_f - E_x}\right)$$

Under this condition (no synchronizing signal applied) the oscillator is said to be "free running."

(3) When a positive synchronizing voltage is applied to the grid, the firing potential of the tube is reduced. The tube therefore ionizes at a lower plate potential than when no grid signal is applied. Thus the applied synchronizing voltage fires the gas-filled triode each time the plate potential rises to a sufficient value, so that the sweep recurs at the same or an integral sub-multiple of the synchronizing signal rate. A graphic representation of this is shown in Figure 2-7.

5. POWER SUPPLY

a. GENERAL.

Figure 2-8 shows the power supply to be made up of two definite sections: a low voltage positive supply which provides the power for operating the amplifiers, the time base generator, and the positioning circuits of the cathode-ray tube, and the high voltage negative supply which provides the potentials necessary for operating the various electrodes of the cathode-ray tube and furnishes a negative voltage to the positioning controls.

b. THE LOW VOLTAGE POWER SUPPLY.

The low voltage power supply consists of a full wave rectifier, V5. The output of this rectifier is filtered by a capacitor input filter consisting of C7-C, L1, and C7-B. It furnishes B+ at approximately 400 volts at sufficient current to supply the tubes of the instrument.

c. THE HIGH VOLTAGE POWER SUPPLY.

The high voltage power supply employs a half wave rectifier, V4. The output of this rectifier is filtered by a resistance-capacitor filter consisting of C15, R29, and C16. A voltage divider network attached from the output of this filter obtains the proper operating potentials for the various electrodes of the cathode-ray tube.

d. OPERATION FROM 230 VOLT POWER SOURCE.

A terminal strip inside the instrument allows convenient changeover of power transformer connections so that the Type 274-A may be operated from either a 115 or 230 volt power source. All instruments are connected for 115 volt operation at the factory. Refer to the power supply schematic, Figure 2-8, or to the circuit schematic at the back of this manual for proper transformer connections.

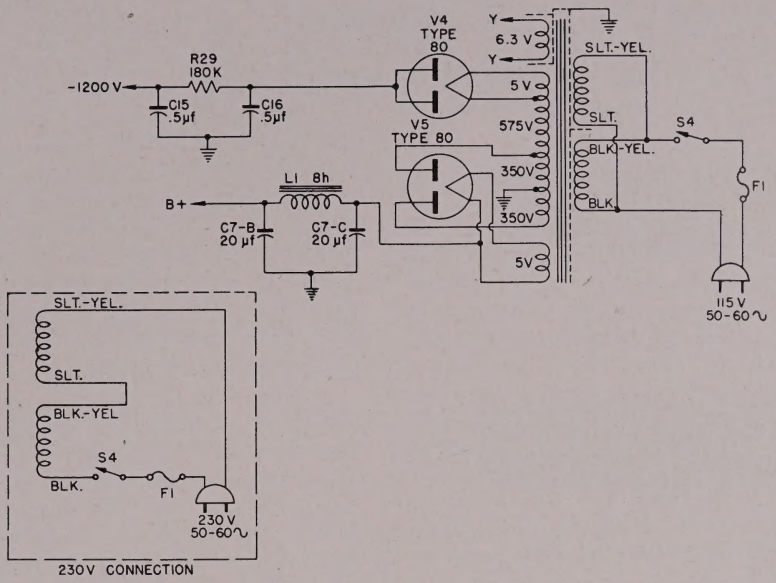


FIGURE 2-8

SCHEMATIC OF POWER SUPPLY

WARNING

OPERATION OF THIS EQUIPMENT INVOLVES THE USE OF HIGH VOLTAGES WHICH ARE DANGEROUS TO LIFE. OPERATING PERSONNEL MUST AT ALL TIMES OBSERVE ALL SAFETY REGULATIONS. DO NOT CHANGE TUBES OR MAKE ADJUSTMENTS INSIDE THE EQUIPMENT WITH THE HIGH VOLTAGE SUPPLY ON. DO NOT DEPEND UPON THE SAFETY SWITCH FOR PROTECTION, BUT ALWAYS REMOVE THE POWER CORD FROM THE LINE OUTLET. UNDER CERTAIN CONDITIONS DANGEROUS POTENTIALS MAY EXIST IN THE CIRCUITS WITH POWER CONTROLS IN THE OFF POSITION DUE TO CHARGES RETAINED BY CAPACITORS. TO AVOID SHOCK AND SEVERE BURNS ALWAYS DISCHARGE AND GROUND CIRCUITS PRIOR TO TOUCHING THEM. NEVER SERVICE OR ADJUST THE INSTRUMENT WITHOUT THE PRESENCE OR ASSISTANCE OF ANOTHER PERSON CAPABLE OF RENDERING AID.

SECTION III

OPERATING INSTRUCTIONS

1. INSTALLATION

In most instances, the Type 274-A Cathode-ray Oscillograph is shipped with all tubes in place and ready for operation, including the cathode-ray tube. However, in some instances, the cathode-ray tube may be packed separately.

To install the cathode-ray tube the chassis must be removed from the cabinet. Two screws near the bottom of the rear panel hold the chassis in place. Remove these two screws, and unwind the power cord from its bracket. If the edge of the front panel is grasped with the fingers, the instrument may be slid forward out of the cabinet. The power cord and its plug will conveniently feed through the hole provided in the rear of the cabinet.

Insert the cathode-ray tube through the front panel and tube shield as far as the socket. The socket prongs are then inserted into the correct position in the socket. A gentle push, with one hand on the face of the tube and the other hand supporting the tube socket, will seat the tube in the socket.

Before replacing the chassis in the cabinet, it will be well to see that all tubes are properly seated in their sockets. All tube locations are clearly indicated on the chassis. It is also advisable to inspect for any mechanical damage which may have occured in transit.

As soon as these operations have been completed, place the instrument back in its cabinet, and replace the screws.

2. PRECAUTIONS

WARNING

IT IS INADVISABLE TO OPERATE THIS CATHODE-RAY OSCILLOGRAPH WITH THE CASE REMOVED. DANGEROUS POTENTIALS AS HIGH AS 1200 VOLTS ARE EMPLOYED IN THIS INSTRUMENT AND SHOULD BE TREATED WITH PROPER CAUTION.

a. MAGNETIC AND ELECTRIC FIELDS.

Magnetic and electrostatic shielding has been provided in this instrument. However, operation of the instrument in strong fields such as are found near transmitters, transformers, and power generating equipment, etc., may introduce spurious deflections.

Electrostatic pick-up may be minimized by the use of shielded input cables and connections and with a good electrical ground on the chassis of the instrument. Spurious magnetic deflections may be eliminated or reduced to an unobjectionable point by removing the instrument from the immediate vicinity of the disturbance; orienting the instrument in the field so that spurious deflection is at a minimum; or in extreme cases, by adding additional magnetic shielding in the form of a large iron or steel container in which the entire instrument may be placed.

b. POWER REGULATION.

The Type 274-A is designed to operate at a power line voltage of 115 or 230 volts a.c. at a frequency of 50 to 60 cycles per second. Steady variations of $\pm 10\%$ from the normal line voltage will cause little change in the operation of this instrument. Greater changes than this may cause the power supply to operate erratically and the operation of the instrument to become unsatisfactory. For conditions where power line variations are excessive, the manufacturer recommends the use of constant voltage transformers placed in the power line to the instrument. If such a regulator is used, the precautions of Paragraph 2a. should be observed.

c. SCREEN BURNING.

When a small spot or line of high intensity is allowed to remain stationary on the screen of the cathode-ray tube, the entire energy of the beam is concentrated over a very small area and the power imput per unit screen area is high. Under such conditions the screen is susceptible to burning and discoloration.

It is well to note that burning of the screen, until carried to excess, will in no way impair the operation of the tube, since the burning is localized to small areas, and the burned area is not completely insensitive.

3. OPERATION OF CONTROLS

a. GENERAL.

The operation of the various controls of the Type 274-A is presented in a brief tabular form in Table 3-1. Figure 3-3 is available for use with the table in locating these various controls.

For the operator who is well acquainted with oscillographs, this table will probably furnish sufficient instructions to operate the instrument. To the new operator, however, the following discussion lists a step by step procedure for the efficient operation of the instrument. It is suggested that the new operator follow this procedure in learning the use of each of the operating controls.

b. PREPARING THE EQUIPMENT FOR OPERATION.

Step 1. Locate the oscillograph on a level table or bench so the screen of the cathode-ray tube is in full view and a minimum amount of light is reflected from the face of the tube. The location must be sufficiently near a 115 or 230 volt a-c power source to be reached easily by the line cord of the instrument.

Step 2. Set the controls as follows:

VERTICAL POSITIONING	— pointing up
HORIZONTAL POSITIONING	— pointing up
INTENSITY	— OFF
FOCUS	— at 50
VERTICAL AMP	— at 0
HORIZONTAL AMP	— at 20
COARSE FREQUENCY	— on the line between 30 and 150
FINE FREQUENCY	— at 100
SYNC. AMP.	— at 0
SYNC. SELECTOR switch	— EXT
VERTICAL INPUT switch	— AMP

Step 3. Plug the line cord into a power source of 115 or 230 volts at 50-60 cycles.

c. OBTAINING THE TRACE.

Step 1. Turn on the equipment by rotating the INTENSITY control clockwise and set it at 50. The jeweled light located in the lower center of the front panel glows green when the equipment is turned on.

WARNING

NEVER ADVANCE THE INTENSITY CONTROL TO A POSITION WHICH CAUSES AN EXCESSIVELY BRIGHT SPOT TO APPEAR ON THE SCREEN. A VERY BRIGHT SPOT MAY BURN THE SCREEN AND DECREASE THE LIFE OF THE CATHODE-RAY TUBE. FOR THIS REASON A SHARPLY FOCUSED TRACE OR SPOT OF HIGH INTENSITY MUST NEVER BE PERMITTED TO REMAIN STATIONARY FOR ANY LENGTH OF TIME.

Step 2. Allow 30 seconds for the instrument to warm up.

Step 3. If no trace becomes visible near the center of the cathode-ray tube screen, advance the INTENSITY control until a trace is visible.

Step 4. Rotate the FOCUS control as required to the position where the trace is clear and sharp (least "fuzzy"). The trace then is described as being "in focus." Once in focus, both clockwise and counterlockwise movement of the FOCUS control defocuses the spot. Having reached a clear focus, the operator may decide that the trace is too bright. If such is the case, reduce the setting of the INTENSITY control and refocus. Figures 3-1 and 3-2 show a trace respectively "in focus," and "out of focus."

FIGURE 3-1
TRACE "IN FOCUS"

FIGURE 3-2
TRACE "OUT OF FOCUS"

Note

The action of the INTENSITY and FOCUS controls are inherently dependent on each other. Therefore, it may be necessary, whenever varying one control, to adjust the other control to obtain the best definition of the trace.

Step 5. Rotate the VERTICAL POSITIONING control counterclockwise (DOWN) and clockwise (UP). The trace moves down and then up as the control is turned. Center the trace in the vertical plane.

Step 6. Rotate the HORIZONTAL POSITIONING control counterclockwise (LEFT) and clockwise (RIGHT). The trace moves left and then right as the control is turned. Center the trace in the horizontal plane. The trace is centered horizontally when the ends of the trace are equally distant from their respective edges of the tube screen.

d. CONTROL OF FREQUENCY OF THE TRACE.

The trace that has just been obtained and positioned is actually a single spot which is being caused to move rapidly and repeatedly across the screen from left to right. As this beam moves across the screen the persistence of the human vision plus the persistence of the screen, causes the movement of this spot to blend into a continuous line as has been previously explained in Section 2, paragraph 1.c. The operator may prove this point to his own satisfaction by the following procedure:

Step 1. Set the COARSE FREQUENCY switch to HOR. INPUT AMP. A spot, which is approximately round and possesses a very small diameter, should appear on the face of the cathode-ray tube. This spot will remain stationary.

TABLE 3-1
TABLE OF OPERATING CONTROLS AND TERMINALS

Name of Control	*Circuit Desig.*	*Component*	*Function*
VERTICAL POSITION	R19	1 megohm potentiometer	Changes the d-c potential on the vertical deflection plate and thus the vertical position of the trace.
HORIZONTAL POSITION	R14	1 megohm potentiometer	Changes the d-c potential on the horizontal deflection plate and thus the horizontal position of the trace.
INTENSITY	R21	100,000 ohm potentiometer	Varies the voltage on the cathode of the cathode-ray tube and thus the intensity of the trace.
FOCUS	R23	500,000 ohm potentiometer	Varies the voltage on the focusing electrode of the cathode-ray tube and thus adjusts the focal point of the beam.
VERTICAL AMP	R1	1 megohm potentiometer	Varies the voltage of the input signal as it is applied to the grid of the vertical amplifier, thus controlling the amplitude of the vertical signal.
HORIZONTAL AMP	R4	1 megohm potentiometer	Varies the voltage of the input signal as it is applied to the grid of the horizontal amplifier, thus controlling the amplitude of the horizontal signal (whether signal is from the time-base generator or an external source).
COARSE FREQUENCY	S3	2 gang, 4 pole 7 position rotary switch	Switches to the various sweep capacitators as well as to positions for connecting an external signal, capacitively to the deflection plates, or through the horizontal amplifier.
FINE FREQUENCY	R28	5 megohm potentiometer	Provides a fine adjustment of the sweep frequency by controlling the rate at which the selected sweep capacitor is charged.
SYNC. AMP.	R10	100,000 ohm potentiometer	Varies the ampltitude of the synchronizing voltage applied to the time-base generator thus enabling the operator to "lock-in" the signal being viewed.
VERTICAL INPUT	S2	Double pole double throw toggle switch	Switches the vertical input signal to the grid of the vertical amplifier or capactively to the vertical deflection plate.
SYNC. SELECTOR	S1	Single pole double throw toggle switch	Provides a means for the operator to select a synchronizing signal from either an internal or an external source.
VERTICAL INPUT		Binding Post	Provides a terminal for the connection of an external signal to the vertical channel.
HORIZONTAL INPUT		Binding Post	Provides a terminal for the connection of an external signal to the horizontal channel.
INTENSITY MOD.		Binding Post	Provides a terminal for the connection of an external signal to the grid of the cathode-ray tube for the purpose of modulating the intensity of the trace.
TEST SIGNAL		Binding Post	Provides a terminal for a 60 cycle output voltage of approximately 6 volts a-c.
EXT. SYNC.		Binding Post	Provides a terminal for connecting an external synchronizing signal.
GROUND		Binding Post (Two)	These binding posts are available to ground the chassis of the Type 274-A to the ground of any input signals.

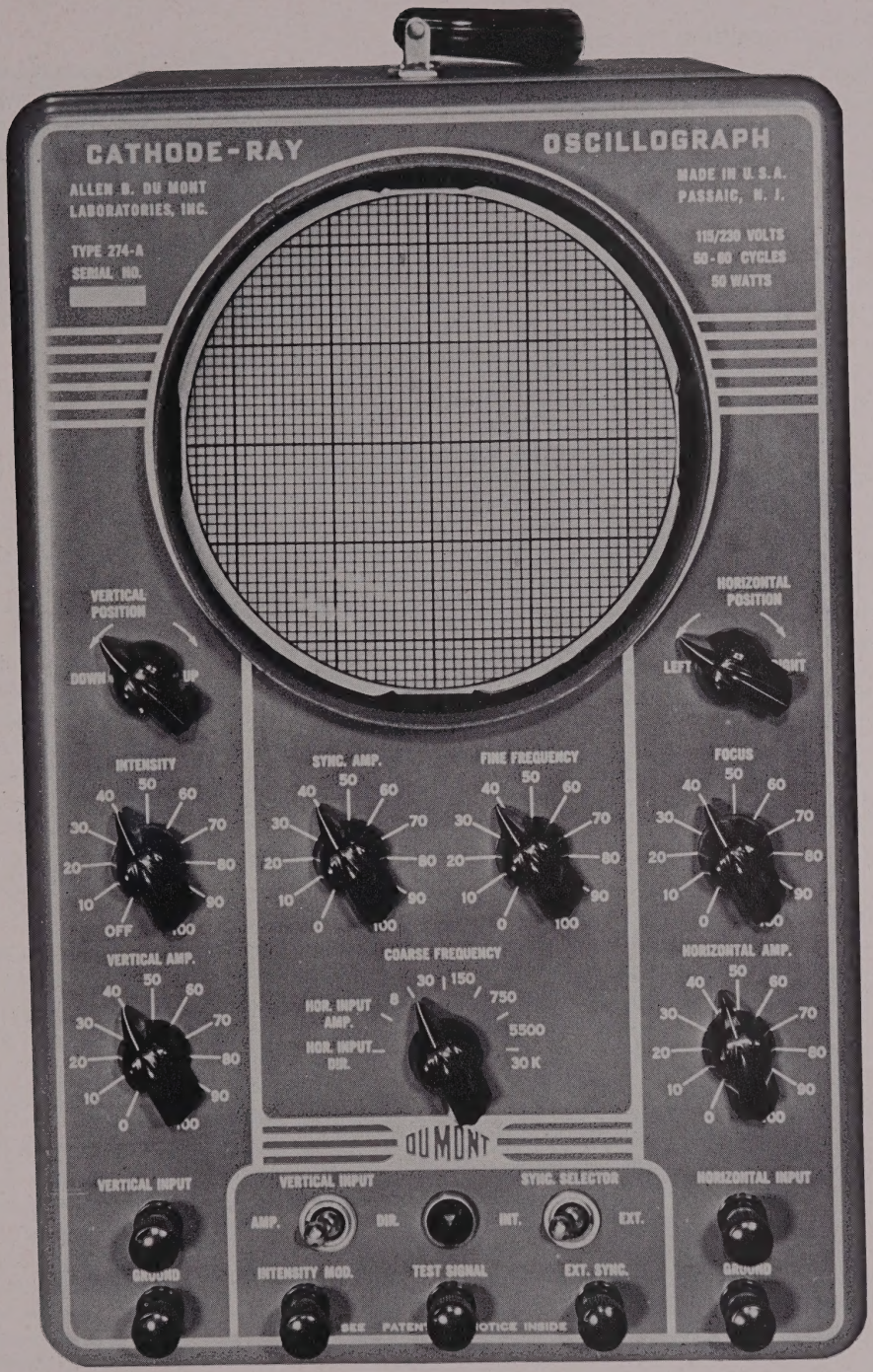


FIGURE 3-3

FRONT PANEL VIEW OF TYPE 274-A CATHODE-RAY OSCILLOGRAPH

CAUTION

Immediately after this spot has been observed, turn the COARSE FREQUENCY switch to the position between 8 and 30. This precaution is observed to avoid burning the tube screen by leaving a spot in one position on the screen.

Step 2. With the COARSE FREQUENCY switch set between 8 and 30, turn the FINE FREQUENCY control to 0.

The operator will observe that the spot which was obtained in the preceding step is now being caused to sweep across the face of the cathode-ray tube.

Step 3. By advancing the FINE FREQUENCY control slowly towards 100, the operator can observe that this spot is caused to sweep more and more rapidly across the screen. As the FINE FREQUENCY control reaches about 50 or 60 this spot will have blended into a solid line which appears to be flickering (varying in intensity). As the FINE FREQUENCY control approaches the 100, the flicker of this trace becomes negligible because the frequency of the sweep generator is now equal to, or above that frequency which produces persistence of vision.

By means of the two controls, the FINE FREQUENCY control, and the COARSE FREQUENCY switch, the frequency of the sweep generator can be adjusted to any frequency between 8 and 30,000 cycles per second. (It is an inherent characteristic of this instrument for the trace to become reduced in length as the frequency is increased and does not denote trouble.)

e. CONTROL OF LENGTH OF TRACE.

The length of the trace is controlled by the HORIZONTAL AMP control. For the lower frequencies a maximum setting of the HORIZONTAL AMP control will cause the sweep to extend beyond the limits of the face of the tube. By setting the HORIZONTAL AMP control to 0, a spot is obtained on the cathode-ray tube because the signal from the sweep generator which causes the displacement of the spot from the center of the tube is at 0.

f. DISPLAYING A SINE WAVE.

Preliminary Setting: VERTICAL AMP-20.

Step 1. Connect a short wire from the TEST SIGNAL terminal to the VERTICAL INPUT terminal. The test signal is an a-c signal of approximately 6 rms volts amplitude.

Step 2. With the COARSE FREQUENCY control set at the 30-150 position, rotate the FINE FREQUENCY control until a sine wave (Figure 3-4) of one or more cycles can be identified on the screen. As the FINE FREQUENCY control is set towards the low frequency end of its scale (0), more cycles of the sine wave should appear.

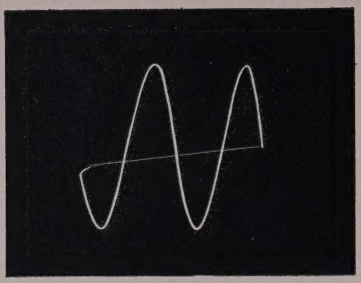


FIGURE 3-4
SINE WAVE

Step 3. Stop the drifting of this wave as nearly as possible with the FINE FREQUENCY control. Regardless of this setting there will always be a slight drift.

Step 4. Set SYNC SELECTOR switch to INT. This setting permits part of the signal which is passing through the vertical amplifier to be impressed on the grid of the time-base generator thereby synchronizing the time-base generator to a submultiple of the wave passing through the vertical amplifier. The amplitude of the synchronizing voltage applied depends upon the setting of the SYNC AMP control. The theory of synchronization is explained more fully in Section 2.

Step 5. Increase the setting of the SYNC AMP control until the trace can be seen to "lock in."

CAUTION

Never use a higher setting of the SYNC AMP control than is necessary or the image may be distorted.

g. MODULATING THE INTENSITY OF THE TRACE.

Step 1. Obtain two complete sine waves on the screen of the cathode-ray tube by the method explained in the preceding paragraph f.

Step 2. Connect a short wire between the TEST SIGNAL and INTENSITY MOD. terminals. (Do not remove the wire between the VERTICAL INPUT and TEST SIGNAL terminals.)

Step 3. Reduce the intensity of the trace with the INTENSITY control (while maintaining focus with the FOCUS control) until the bottom peaks of the sine wave disappear. It will also be noted that as the bottom peaks are blanked out, the upper peaks are intensified. This is the result of using a sine wave as the modulating signal. The result just described is called *intensity modulation* and is discussed more fully under Laboratory and Lecture Applications.

WARNING

NEVER APPLY AN INTENSITY MODULATING SIGNAL LARGE ENOUGH TO SWING THE GRID OF THE CATHODE-RAY TUBE POSITIVE WITH RESPECT TO THE CATHODE. THIS UNWANTED CONDITION MAY CAUSE A SERIOUS REDUCTION IN THE LIFE OF THE CATHODE-RAY TUBE. AN INDICATION OF THE GRID SWINGING POSITIVE WITH RESPECT TO THE CATHODE IS RECOGNIZED BY MARKED DEFOCUSING ON THE SCREEN DURING THE POSITIVE PHASE 0F THE INTENSITY MODULATING SIGNAL.

Note

It is advisable to connect a short lead from the INTENSITY MOD terminal to GROUND when this terminal is not in use. Such a connection results in a trace of more uniform intensity.

h. CONTROLLING THE SIZE OF THE PATTERN.

It is frequently desirable to examine more closely a particular part of a pattern or trace. In that event the pattern or trace may be expanded both horizontally and vertically by increasing the setting respectively of the HORIZONTAL AMP and VERTICAL AMP controls. These expanded traces may then be positioned to any part of the screen to obtain better definition of the part in question. Care should be taken, however, to assure that the amplifiers are not overloaded by this procedure, or the wave form under examination will be distorted.

Note

All signals applied to the oscillograph from external sources require two wires to complete the connection. One wire carries the signal and the other wire serves as a ground. This results in all the signals, being observed or performing a function in the oscillograph, being referred to a common ground.

i. THE USE OF EXTERNAL SYNC.

In many cases, an external signal is more suitable for synchronizing purposes than the signal applied to the vertical channel. This is particularly true if varying amplitudes of the same wave form are to be viewed in rapid succession. Since when using internal sync, the amplitude of the wave form passing through the vertical amplifiers also affects the amplitude of the synchronizing voltage; too much or too little voltage will be applied to the sync generator with different amplitudes of input signals. Thus the setting of the SYNC AMP control will necessarily require adjustment with each different amplitude of signal applied.

When using an external synchronizing voltage, connection is made from the external source to the EXT. SYNC terminal and the SYNC SELECTOR switch is thrown to the EXT position. Once the SYNC AMP control has been adjusted to apply the correct amount of synchronizing signal to the sweep generator, it will not be necessary to reset it as the various amplitudes of the signal are applied to the vertical channel. It will be necessary to use an external synchronizing voltage whenever the vertical amplifier is not used and the signal is capacitively or directly coupled to the deflection plates.

j. VERTICAL INPUT DIRECT.

If the signal which is connected through the VERTICAL INPUT terminals is of sufficient amplitude to result in appreciable vertical deflection without amplification, the VERTICAL INPUT switch may be set on DIR. This connection capacitively couples the input signal to the vertical deflection plate of the cathode-ray tube and permits the signal to be viewed without amplification.

k. HORIZONTAL INPUT DIRECT.

For certain applications it is frequently necessary to apply a signal other than the time-base signal to the horizontal deflection plate. When such an occasion arises, the COARSE FREQUENCY switch should be turned to the HOR INPUT DIR position and an external signal should be connected to the HORIZONTAL INPUT terminal and GROUND. When the COARSE FREQUENCY switch is set in this position, the signal at the HORIZONTAL INPUT terminal is capacitively coupled to the horizontal deflection plate.

l. HOR INPUT AMP.

If the signal applied to the HORIZONTAL INPUT terminal in the preceding paragraph is not of sufficient amplitude to result in satisfactory horizontal deflection, it may be connected through the horizontal amplifier by switching the COARSE FREQUENCY switch to the HOR INPUT AMP position. Under these circumstances, the horizontal amplifier is used to increase the amplitude of the horizontal signal and the desired deflection is obtained by the HORIZONTAL AMP control.

m. DIRECT DEFLECTION.

The rear terminal strip is designed to provide means for eliminating the capacitor input to the deflection plates when it is desirable to connect a d-c signal directly to the deflection plate.

If it is desirable to connect such a signal to the VERTICAL deflection plate, it should be connected to the rear terminal marked D4. It is advisable to remove the jumper passing between the terminal marked VERT and D4 as shown in Figure 3-5.

If it is desirable to connect an external signal to the HORIZONTAL deflection plate, the connection should be made to the terminal Marked D1. Likewise, the jumper between HOR and D1 should be removed.

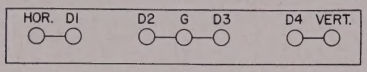


FIGURE 3-5
REAR TERMINAL BOARD

CAUTION

Connections to these terminals should be made with the power turned OFF.

n. TURNING OFF THE EQUIPMENT.

To turn off the equipment, rotate the INTENSITY control counterclockwise to the OFF position. When the equipment is operating but not in use, turn the INTENSITY control sufficiently counterclockwise to dim out the trace. This procedure will insure against burning the screen of the cathode-ray tube and increase its life.

4. DISPLAY OF WAVEFORMS

Together with a working acquaintance of the controls of the oscillograph, an understanding of how the patterns are traced on the screen must be obtained for a thorough knowledge of oscillograph operation. With this in mind a careful analysis of two fundamental patterns is discussed under the following headings:

a. Patterns plotted against time (using the sweep generator for horizontal deflection)
b. Lissajous Figures (using a sine wave for horizontal deflection)

a. PATTERNS PLOTTED AGAINST TIME.

(1) Preliminary.—A sine wave is typical of and convenient for this study. The connections necessary for producing a sine wave on the screen were previously discussed. This wave is amplified by the vertical amplifier and impressed on the vertical (Y-axis) deflection plate. Simultaneously the sawtooth wave, as discussed in Section 2, from the time-base generator is amplified and impressed on the horizontal (X-axis) deflection plates.

(2) Theory.—The electron beam moves in accordance with the resultant of the sine and sawtooth signals. The effect is shown in Figure 3-6 where the sine and sawtooth waves are graphically represented on time and voltage axes. Points on the two waves that occur simultaneously are numbered similary. For example, 2 on the sine and 2 on the sawtooth waves occur at the same instant. Therefore, the position of the beam at instant 2 is the resultant of the voltages on the horizontal and vertical deflection plates in instant 2. Referring to Figure 3-6, by projecting lines from point 2, the position of the electron beam at instant 2 can be located. If projections were drawn from every other instantaneous position of each wave to intersect on the circle representing the tube screen, the intersections of similarly timed projections would trace out a sine wave.

(3) Conclusion.—In summation, Figure 3-6 illustrates the principles involved in producing a sine wave trace on the screen of a cathode-ray tube. Each intersection of similarly timed projections represents the position of the electron beam acting under the influence of the varying voltage waveforms on each pair of deflection plates. Figure 3-7 shows the effect on the pattern of decreasing the frequency of the sawtooth wave. Any recurrent waveform plotted against time can be displayed and analyzed by the same procedure as used in these two examples.

(4) Other Patterns.—The sine wave example just illustrated is typical of the method by which any wave form can be displayed on the screen of the cathode-ray tube. Such wave forms as square wave, sawtooth wave, and many other more irregular recurrent wave forms can be observed by the same method explained in the preceding paragraphs.

b. LISSAJOUS FIGURES.

(1) Preliminary.—Another fundamental pattern is the Lissajous figure, named after the 19th century French scientist. This type of pattern is of particular use in determining the frequency ratio between two sine wave signals. If one of these signals is known, the other can

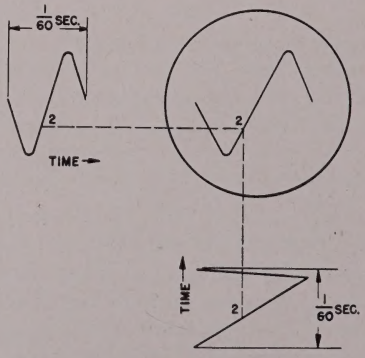


FIGURE 3-6
PROJECTION DRAWING OF A SINEWAVE APPLIED TO THE VERTICAL AXIS AND A SAWTOOTH WAVE OF THE SAME FREQUENCY APPLIED SIMULTANEOUSLY ON THE HORIZONTAL AXIS

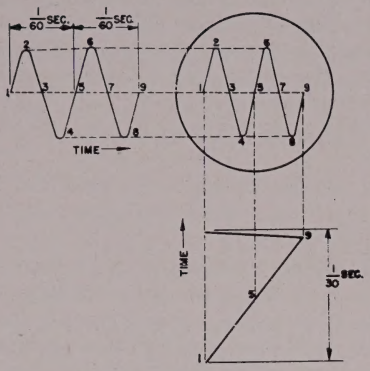


FIGURE 3-7

PROJECTION DRAWING SHOWING THE RESULTANT PATTERN WHEN THE FREQUENCY OF THE SAW-TOOTH IS ONE-HALF OF THAT EMPLOYED IN FIGURE 3-6

be quickly calculated from the ratio. Common practice is to connect the known signal to the horizontal channel and the unknown to the vertical channel. The amplifiers may or may not be used depending upon the amplitude of the signals and their frequencies.

(2) Theory.—The presentation of Lissajous figures can be analyzed by the same method as previously used for sine wave presentation. A simple example is illustrated in Figure 3-8. The frequency ratio of the signal on the horizontal axis to that on the vertical axis is 3 to 1. If the known signal on the horizontal axis is 60 cycles per second, the signal on the vertical axis is 20 cycles.

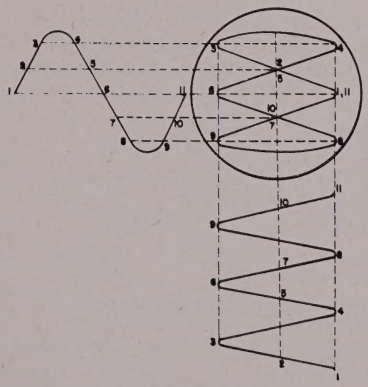


FIGURE 3-8

PROJECTION DRAWING SHOWING THE RESULTANT LISSAJOUS PATTERN WHEN A SINE WAVE APPLIED TO THE HORIZONTAL AXIS IS THREE TIMES THAT APPLIED TO THE VERTICAL AXIS

The Lissajous pattern is traced by joining intersections of projections from like numbered points on the signals. The frequency relationship, determined by the ratio of the number loops touching two mutually perpendicular sides, is calculated most readily when the two signals are out of phase. For example, Figure 3-9 shows a complex Lissajous figure. The vertical line, AB is touched by 5 loops and the horizontal line BC is touched by 3 loops. The ratio of the frequency on the horizontal axis is to the frequency on the vertical axis as the number of loops which intersect line AB is to the number of loops which intersect line BC.

Algebraically:

$$\frac{\text{Frequency on horizontal Axis}}{\text{Frequency on vertical Axis}} = \frac{\text{Number of loops intersecting AB}}{\text{Number of loops intersecting BC}}$$

(3) Obtaining a Lissajous Pattern on the screen.

Preliminary Settings:

COARSE FREQUENCY—HOR INPUT AMP

VERTICAL INPUT switch—AMP

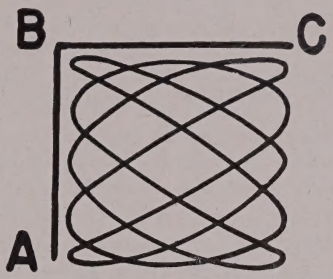


FIGURE 3-9

METHOD OF CALCULATING FREQUENCY RATIO OF LISSAJOUS FIGURES

Step 1. Connect a wire from the TEST SIGNAL terminal to the HORIZONTAL INPUT terminal.

Step 2. Place an audio oscillator conveniently near the oscillograph, and connect its output and ground terminals to the VERTICAL INPUT and GROUND terminals of the Type 274-A oscillograph.

Step 3. Switch the oscillograph and the audio oscillator into operation.

Step 4. Locate a pattern of convenient size in the center of the screen by adjusting the positioning and amplitude controls.

Step 5. By adjusting the frequency of the audio oscillator obtain a pattern that is nearly stationary. It is not necessary to stop the pattern, but merely to slow it up enough to count the loops at the sides of the pattern.

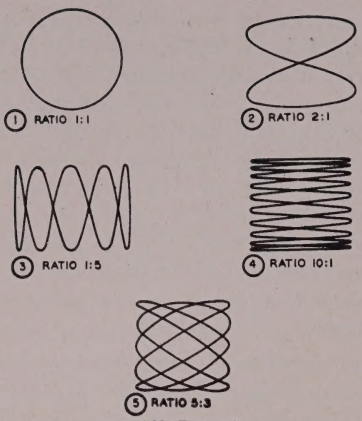


FIGURE 3-10

OTHER LISSAJOUS PATTERNS

Step 6. Count the number of loops which intersect an imaginary vertical line AB and the number of loops which intersect the imaginary horizontal line BC as in Figure 3-9. The ratio of the number of loops which intersect AB is to the number of loops which intersect BC as the frequency of the horizontal signal is to the frequency of the vertical signal.

(4) More examples of Lissajous Patterns.—Figure 3-10 shows other examples of Lissajous figures. In each case the frequency ratio shown is the frequency ratio of the signal on the horizontal axis to that on the vertical axis.

(5) Phase Difference Patterns.

(a) Introduction.—Coming under the heading of Lissajous figures is the method used to determine the phase difference between signals of the same frequency. The patterns involved take on the form of ellipses with different degrees of eccentricity.

(b) Obtaining the Phase-Difference Pattern. To obtain an accurate pattern from which phase difference can be determined, the following procedure must be followed:

Step 1. Turn the VERTICAL AMP control and the HORIZONTAL AMP control to 0 and with the calibrated screen in place, center the spot on the screen of the cathode-ray tube.

Step 2. Connect one signal to the VERTICAL INPUT terminal and the other signal to the HORIZONTAL INPUT terminal.

Step 3. Connect a common ground between the two frequencies under investigation and the oscillograph.

Step 4. If the frequency of the signals is less than 100 KC set the COARSE FREQUENCY switch to HOR INPUT AMP and the VERTICAL INPUT switch to AMP.

Step 5. If these frequencies are more than 100 KC, set the COARSE FREQUENCY switch to HOR INPUT DIR and the VERTICAL INPUT switch to DIR.

Step 6. Assuming the signals to be less than 100 KC, the COARSE FREQUENCY switch is set on HOR INPUT AMP and the VERTICAL INPUT switch is set on AMP.

Step 7. Adjust the VERTICAL AMP control to give approximately 3 inches of vertical deflection and adjust the calibrated scale so that the vertical axis of the scale coincides precisely with vertical deflection of the spot.

Step 8. Be extremely careful not to change the setting of the VERTICAL AMP control even the slightest amount. Remove the signal from the VERTICAL INPUT terminal and the trace will collapse to form a spot again.

Step 9. Increase the setting of the HORIZONTAL AMP control to give a deflection exactly the same as that to which the VERTICAL AMP control is adjusted (3 inches).

Step 10. Again connect the signal which was just removed from the VERTICAL INPUT terminal.

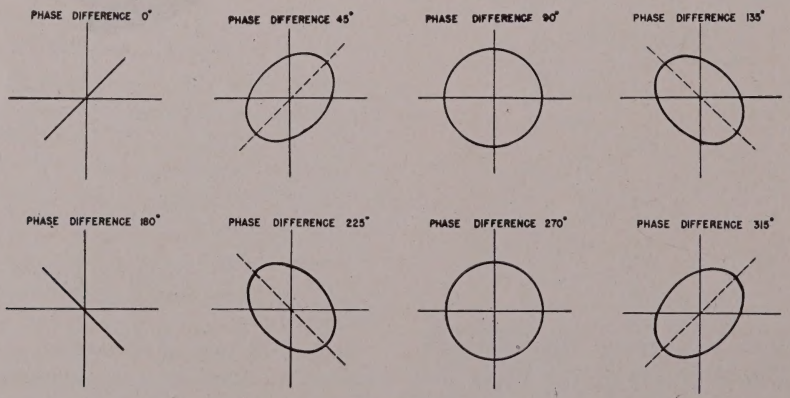


FIGURE 3-11

LISSAJOUS PATTERNS OBTAINED FROM THE MAJOR PHASE DIFFERENCE ANGLES

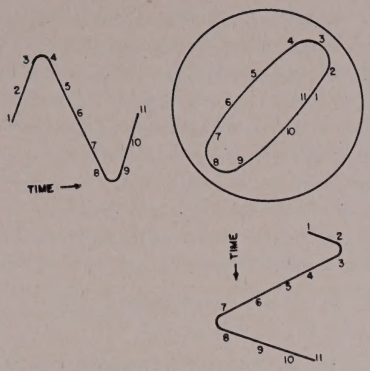


FIGURE 3-12

PROJECTION DRAWING SHOWING THE RESULTANT PHASE DIFFERENCE PATTERN OF TWO SINE WAVES 45° OUT OF PHASE

The resulting pattern will give an accurate picture of the exact phase difference between the two waves. If these two patterns are exactly the same frequency but different in phase and maintain that difference, the pattern on the screen will remain stationary. If, however, one of these frequencies is drifting slightly, the pattern will drift slowly through 360°. The phase angles of 0°, 45°, 90°, 135°, 180°, 225°, 270°, 315° are shown in Figure 3-11.

(c) Presentation.—Each of the eight patterns in Figure 3-11 can be analyzed separately by the previously used projection method. Figure 3-12 shows two sine waves which differ in phase being projected on to the screen of the cathode-ray tube. These signals represent a phase difference of 45°.

Note

It is extremely important: (1) that the spot has been centered on the screen of the cathode-ray tube, (2) that both the horizontal and vertical amplifiers have been adjusted to give exactly the same gain, and (3) that the calibrated scale be originally set to coincide with the displacement of the signal along the vertical axis.

If the amplifiers of the oscillograph are not used for conveying the signal to the deflection plates of the cathode-ray tube, the COARSE FREQUENCY switch should be set to HOR INPUT DIR and the VERTICAL INPUT switch to DIR and the outputs of the two signals must be adjusted to result in exactly the same vertical deflection as horizontal deflection. Once this deflection has been set by either the oscillator output controls or the amplifier gain controls in the oscillograph, it should not be changed for the duration of the measurement.

(d) Determination of the Phase Angle.—The relation commonly used in determining the phase angle between signals is:

$$\text{Sine } \theta = \frac{\text{Y intercept}}{\text{Y maximum}}$$

where θ = phase angle between signals

Y intercept = point where ellipse crosses vertical axis measured in tenths of inches. (Calibrations on the calibrated screen)

Y maximum = highest vertical point on ellipse in tenths of inches

Several examples of the use of the formula are given in Figure 3-13. In each case the points Y intercept and Y maximum are indicated together with the sine of the angle and the angle itself.

(e) Phase Shifters.—For the operator to observe these various patterns with a single signal source such as the test signal, there are many types of phase shifters which

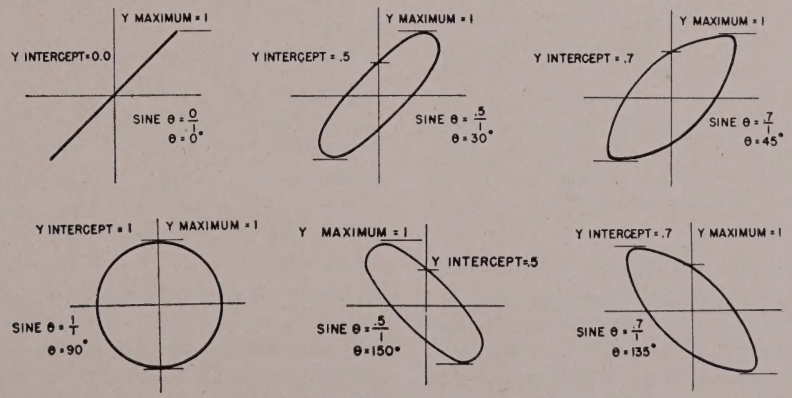


FIGURE 3-13

EXAMPLES SHOWING THE USE OF THE FORMULA FOR DETERMINATION OF PHASE DIFFERENCE

can be used. Circuits can be obtained from a number of radio text books. The procedure is to connect the original signal to the horizontal channel of the oscillograph and the signal which has passed through the phase shifter to the vertical channel of the oscillograph, and follow the procedure set forth in this discussion to observe the various phase shift patterns.

c. OTHER TIME BASES.

Numerous new applications have been developed and are being developed daily. Many of these applications require time bases which are different from either the sawtooth time base or the sine wave time base just discussed. These applications are too numerous and too specialized to be considered to any great extent in this instruction book. However, some special types of time bases are listed as follows: 1. Circular sweep. 2. Spiral sweep. 3. Radial sweep. 4. Delayed sweeps. 5. Expanded sweeps.

5. LECTURE AND LABORATORY APPLICATIONS

a. INTRODUCTION.

The cathode-ray oscillograph is an ideal instrument for lecture demonstration and laboratory experiments in conjunction with the subjects of light, sound, electricity, and electronics. The Du Mont Type 274-A Cathode-ray Oscillograph was developed with this function being one of the primary design considerations. It is suggested that instructors and lecturers in the field of electronics prepare a series of demonstration units to aid in the explanation of the theory of the various electronic circuits. If these circuits are designed so that the critical components are variable, the effects on the waveforms at various points in the circuit can be demonstrated very clearly with the Type 274-A cathode-ray oscillograph.

In addition to its use with the demonstration units, many further uses can be found when the instrument is available in the laboratory and the operator becomes familiar with its versatility. For instance, it serves as: (1) an excellent null-indicator for inductance-capacitance bridges, (2) as a means for viewing voltage wave forms in various electronic circuits, (3) as an output meter, (4) a means for measuring time and amplitude of electrical impulses, (5) as an indicator in studies pertaining to sound and light, and many other applications.

b. DEMONSTRATION UNITS.

As an example of the use of a typical demonstration unit, the following demonstrations and experiments can be conducted with a single-stage audio-amplifier: measurement of frequency response versus gain; effect of screen and cathore impedances; measurement of pentode and triode characteristics; phase distortion; square wave testing; and microphone operation. A demonstration unit which is prepared on a typical power supply would derive its power directly from an a-c power line. Such a unit is very convenient to demonstrate the following: full-wave rectification, half-wave rectification, the various filtering networks, and voltage regulation by means of bleeders.

The demonstrations suggested herein are merely to present ideas as to how the 274-A may be used as a demonstrator. It is left to the individual instructor to incorporate this instrument into his course of study as he sees fit.

c. NULL-INDICATOR FOR INDUCTANCE-CAPACITANCE BRIDGES.

(1) General.—Precise measurements by the bridge method require a sensitive null-indicator. Since bridges for measurements of inductance and capacitance utilize an a-c signal, the oscillograph is probably the most sensitive null-indicator. With the Type 274-A amplifier at full gain approximately one inch deflection on the cathode-ray tube screen results with a signal input voltage of 0.20 volt.

(2) Procedure.

Preliminary Settings

COARSE FREQUENCY	— on the line between 8 and 30
FINE FREQUENCY	— at 0
HORIZONTAL AMP	— to give approximately 3″ horizontal deflection
SYNC AMP	— at 0
VERTICAL INPUT switch	— AMP
SYNC SELECTOR switch	— INT

Step 1. Connect VERTICAL INPUT and GROUND across the terminals provided at the bridge for the null-indicator.

Step 2. Prepare the bridge for testing an unknown quantity.

Step 3. Turn on the bridge signal source.

Step 4. Obtain a pattern of convenient size by adjusting the VERTICAL AMP control (this pattern need not be stationary because amplitude is the only measurement concerned).

Step 5. Adjust the bridge controls to achieve balance indicated by minimum vertical deflection of the pattern on the screen.

Step 6. As the balance point is approached, the deflection on the cathode-ray tube will become less. It will probably be necessary to increase the setting of the VERTICAL AMP control as the balance point is approached so that the oscillograph gives a positive indication as the bridge dial is rotated through the null-point.

Note

Some individuals find it desirable to set the HORIZONTAL AMP control at 0 in using the oscillograph as a null-indicator. The pattern resulting is merely a vertical line which is of minimum length as the bridge dial passes through the null-point. Be sure to keep intensity low if this method is used, in order to avoid burning the screen. Frequency setting is a matter of choice in this case, but some individuals prefer to set the sweep high enough to get a raster and collapse it down by balancing the bridge.

d. PRECISE MEASUREMENT OF ELECTRICAL IMPULSES.

(1) Preliminary.—In many cases the wave form of a signal of unknown frequency prevents the use of a Lissajous figure for frequency determinations. For example, it may be desirable to measure the frequency of a series of pulses. In addition, it may be desirable to measure precisely the duration of a pulse, or the time it requires a pulse to reach its peak amplitude. Measurements such as this may be made by utilizing intensity modulation. Intensity modulation is the result of applying a signal of varying potential to the control grid of the cathode-ray tube thereby varying the intensity of the trace at the frequency of the signal applied.

(2) Procedure for Frequency Measurement by Intensity Modulation.

Preliminary Settings

COARSE FREQUENCY	— on the line between 30 and 150
FINE FREQUENCY	— at 0
SYNC AMP	— at 0
HORIZONTAL AMP	— to give approximately 3″ deflection
VERTICAL INPUT switch	— AMP
SYNC SELECTOR switch	— INT

Step 1. Locate a calibrated audio oscillator, whose output voltage is at least 10 rms volts, conveniently near the oscillograph.

Step 2. Connect the output of the oscillator between INTENSITY MOD and GROUND.

Step 3. Connect TEST SIGNAL to VERTICAL INPUT with a short lead.

Step 4. Turn on the audio oscillator and the oscillograph.

Step 5. Set the calibrated audio oscillator on a multiple of 60 cycles, for example, 480 c.p.s.

Step 6. Locate a pattern of convenient size on the screen.

Step 7. With the FINE FREQUENCY control obtain a trace of two complete cycles and advance the SYNC AMP control sufficiently to "lock in" the pattern.

Step 8. Adjust the INTENSITY control and the voltage output control on the audio oscillator simultaneously until dark spaces are observed on the pattern.

Step 9. Count these dark spots as they appear on the pattern. In this case, we have adjusted the intensity modulation to 480 c.p.s., and the frequency on the vertical channel is 60 c.p.s.; therefore, eight dark spots should occur on each cycle of the pattern being observed as shown in Figure 3-14.

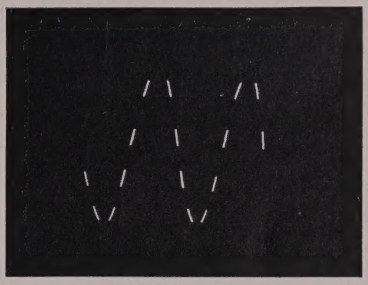


FIGURE 3-14
EXAMPLE OF INTENSITY MODULATION WITH SINE WAVE SIGNAL

Note

To obtain more precise timing markers with a sharp definition of intensity modulation, it is more desirable to use a square wave as the intensity modulating signal. This example was chosen for the instruction book because it is felt that more users would have an oscillator of sine wave output than one with square wave output.

e. USE AS AN OUTPUT METER.

(1) Preliminary.—Among the many important applications of the oscillograph, is its use as an output meter. An output meter, in addition to being merely a voltmeter, must be singular in its ability to indicate the signal strength of signals of all frequencies. The cathode-ray oscillograph is extremely useful in this capacity up to the limits of the frequency response of its vertical amplifier; and the cathode-ray tube itself, can go far beyond this point as discussed in Section 1.

In addition to the fact that the output meter must respond to all frequency signals, another requirement is that the output meter should not act as a load to the cricuit it is measuring. The cathode-ray oscillograph also fulfills this requirement in view of the fact that it possesses extremely high input impedances. An example of the use of the oscillograph for indicating signal strength is given in the following procedure.

(2) Procedure for Measuring Gain of an Amplifier.

(a) Obtain an audio amplifier which may be a homemade "single stage" amplifier, the audio section of a radio receiver, or an audio amplifier demonstration unit.

(b) Set the controls of the Type 274-A Oscillograph to the following positions:

COARSE FREQUENCY	— on the line between 30 and 150
SYNC SELECTOR switch	— INT
VERTICAL INPUT switch	— AMP

Step 1. Assuming that an audio amplifier demonstration unit is used, connect the TEST SIGNAL terminal of the oscillograph to the input grid of the audio amplifier.

Step 2. Connect the VERTICAL INPUT of the oscillograph to the input of the amplifier and connect GROUND of the oscillograph to GROUND of the amplifier.

Step 3. Turn on the oscillograph and the audio amplifier.

Step 4. With the HORIZONTAL AMP and VERTICAL AMP controls, obtain a pattern on the screen of the cathode-ray tube which gives about 3 inches of horizontal deflection and about 2/10″ vertical deflection (the calibrated screen can be used for this measurement).

Step 5. Remove the connection between the VERTICAL INPUT terminal of the oscillograph and the INPUT terminal of the amplifier.

Step 6. Connect the VERTICAL INPUT of the oscillograph to the OUTPUT of the audio amplifier.

Step 7. With the calibrated screen measure the number of inches of vertical deflection.

Step 8. If the vertical deflection is now 3.0″, the gain of the amplifier just measured is 15.

$$\text{gain} = \frac{\text{output voltage}}{\text{input voltage}} = \frac{3.0}{0.2} = 15$$

Note

The gain of this amplifier can also be measured without using horizontal deflection since the input and output signals are both measured on the vertical channel and amplitude is the only measurement being made. It is extremely important, however, that the setting of the vertical amplitude should not be changed between measurements of the input voltage and the output voltage. All voltage measurements under these circumstances are made as peak-to-peak voltage.

f. USE OF THE OSCILLOGRAPH FOR LECTURE DEMONSTRATION.

In explaining electronic and electrical theory, the instructor will find numerous demonstrations for illustrating his lectures which require the use of the cathode-ray oscillograph. For the discussion of such electronic circuits as multivibrators, integrating and differentiating circuits, delay circuits and others, the instructor will find the oscillograph to be an invaluable tool. Magnetic properties of metals and hysteresis can also be investigated. Utilizing the oscillograph in conjunction with the photo-electric cell, offers many more interesting experiments in the study of light. By employing a microphone in conjunction with the oscillograph, phenomena such as resonance and beats will provide other demonstrations. The details of these and other applications are left to the ingenuity and resourcefulness of the instructor. Specific questions pertaining to the use of the oscillograph should be referred to the Manager of Instrument Sales, Allen B. Du Mont Laboratories, Inc., 1000 Main Avenue, Clifton, New Jersey.

6. RADIO TRANSMITTER APPLICATIONS

a. INTRODUCTION.

The Type 274-A Oscillograph is a useful tool for operating and servicing radio transmitters (which procedure, incidentally, can be used as a separate demonstration or experiment). This discussion concerning radio transmitters is directed to the radio instructor, amateur, and commercial transmitter operator and includes instructions for aligning or adjusting, monitoring, and trouble shooting an amplitude-modulated transmitter.

The discussion of the use of the oscillograph for radio transmitters requires familiarity with a basic amplitude-modulated transmitter. Briefly, this type of transmitter consists of two separate channels: the carrier wave, or r-f channel, and the audio frequency, or a-f channel. The carrier wave channel includes: an oscillator, generally crystal controlled; a buffer amplifier, to isolate the oscillator; and an output stage, generally a push-pull, power amplifier. The audio frequency channel generally is made up of: a voltage amplifier; a phase inverter, to obtain two voltage wave-forms 180° out of phase; and a modulator stage, generally push-pull in design. The modulator stage in small transmitters generally feeds into the output stage of the carrier wave channel.

There are many variations of this type of transmitter. For example, several stages of amplification can be used in the a-f and r-f channels, frequency multiplier stages are often employed to operate the transmitter at a higher carrier wave frequency than that of the crystal, the push-pull feature can be replaced by single amplifiers, or modulation can be introduced into a lower-level stage rather than the output stage.

In maintaining an amplitude-modulated transmitter at optimum performance; there are tank circuits, consisting of a capacitor and coil, which must be adjusted to resonate at the crystal frequency, or a harmonic of that frequency (tuning the carrier wave channel). Also, interaction be-

tween grid and plate tank circuits must be minimized (neutralizing the transmitter). Then, the audio frequency channel must be investigated for faithful reproduction of the input signal. (Checking or trouble shooting the audio channel). Next, the output signal of the transmitter must be monitored. Finally, a quick, efficient method of trouble shooting must be developed.

b. ALIGNING THE TRANSMITTER.

(1) Introduction.—The object in aligning the transmitter is to adjust the tank circuits to resonance at the required frequency.

(2) Procedure—

Preliminary Settings:

SYNC SELECTOR	— EXT
COARSE FREQUENCY	— between 750 and 5500
FINE FREQUENCY	— 50
SYNC AMP	— 0
HORIZONTAL AMP	— 20
VERTICAL AMP	— 0
VERTICAL INPUT switch	— DIR

Step 1. Connect a pick-up loop of two or three turns of wire, equipped with shielded leads long enough to extend from the oscillograph to the transmitter, between VERTICAL INPUT and GROUND.

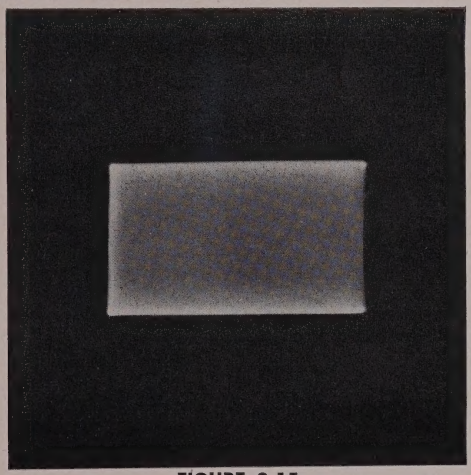


FIGURE 3-15
R-F CARRIER WAVE OF A TRANSMITTER

WARNING

CLOSE COUPLING BETWEEN TANK COIL AND PICK-UP LOOP ALTERS THE RESONANT CONDITION OF THE TANK CIRCUIT. THEREFORE, THIS COUPLING SHOULD NOT BE CLOSER THAN NECESSARY TO OBTAIN SUFFICIENT DEFLECTION ON THE CATHODE-RAY TUBE.

Step 2. Loosely couple the pick-up loop to the tank coil of the oscillator stage of the transmitter.

Step 3. Turn on the oscillograph and transmitter.

Step 4. Obtain a pattern similar to Figure 3-15 by adjusting the coupling between pick-up loop and the tank coil.

Step 5. (Optional.) In the event that the signal picked up is too small to achieve sufficient vertical deflection, construct a high Q tank circuit to resonate at the crystal frequency. Connect the tank circuit in parallel with VERTICAL INPUT and GROUND and adjust its tuning to obtain maximum vertical deflection. If the resultant signal produces more than full scale deflection on the CRT, loosen the coupling between the oscillator coil and the pick-up loop.

Step 6. Adjust the setting of the oscillator tank circuit capacitor until the pattern on the screen reaches maximum vertical deflection. Maximum vertical deflection indicates correct adjustment of the oscillator tank circuit to the crystal frequency.

Step 7. Proceed in order to adjust all other tank circuits of the transmitter with the same method as described above. Frequency multiplier stages are aligned in the same manner except the vertical deflection will be less than that achieved at the preceding fundamental frequency. Remember, however, that as the signal is further amplified, the signal reaching the oscillograph becomes greater and the coupling of the oscillograph can become less in the higher-level stages.

c. NEUTRALIZING THE TRANSMITTER.

(1) Introduction.—The object in neutralizing a transmitter stage is to permit a minimum of signal transfer between the grid and plate tank circuits within any single stage. Neutralization is performed with the transmitter in operation but without plate voltage at the stage to be neutralized.

(2) Procedure—

Step 1. Capacitively couple the oscillograph to the stage to be neutralized as shown in Figure 3-16.

Step 2. The signals from these two sources are connected to the binding post on the front panel of the oscillograph and the VERTICAL INPUT switch is set to DIR and the COARSE FREQUENCY switch is set to HOR INPUT DIR.

Step 3. Tune the grid tank circuit for maximum horizontal signal.

Step 4. Tune the plate tank circuit to produce a horizontal elipse as shown in Figure 3-17A.

Step 5. Tune C_n (the neutralizing capacitor) to obtain a straight horizontal line as shown in Figure 3-17B. The waveforms shown in Figures 3-17C and 3-17D may also be observed. The legend on this figure explains these patterns.

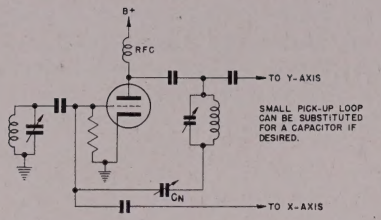


FIGURE 3-16
CAPACITIVE COUPLING FOR NEUTRALIZATION PROCEDURE

d. CHECKING THE A-F CHANNEL.

(1) Introduction.—The a-f channel of a transmitter should have a frequency response which is flat at all audio frequencies in order to faithfully reproduce the audio input signals which it is required to amplify. Since the aging of components may change the frequency response of audio amplifiers, the frequency response of the a-f channel of a transmitter should be checked at regular intervals for the true reproduction.

A customary quick check on the frequency response of an amplifier is accomplished with an audio oscillator. The output of the audio oscillator is first fed into the vertical channel of the oscillograph, but is shunted around the vertical amplifier and capacitively coupled to the vertical deflection plates. The frequency of the audio oscillator is set to the low frequency limit of the a-f channel of the transmitter as set forth in its specification, The frequency of the audio oscillator is then slowly advanced in the direction of the upper frequency limit of the a-f channel of the transmitter. Any deviation in the amplitude of the signal, as shown on the screen of the cathode-ray tube, should be noted along with the frequency at which that deviation occurs. This deviation indicates a change in the output voltage of the audio oscillator at that frequency. If the audio oscillator has a built-in output meter, the output of the oscillator should always be maintained at a constant level and the deviation previously observed on the cathode-ray tube will no longer be apparent. However, if there is no means for controlling the output voltage of the audio oscillator, these deviations should be noted so that the operator will not blame them on the a-f channel about to be tested.

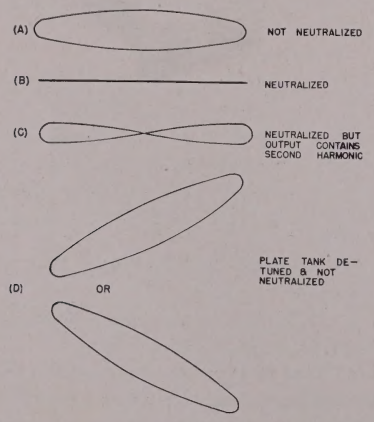


FIGURE 3-17
PATTERNS OBSERVED DURING NEUTRALIZATION

After the output of the audio oscillator has been checked for the frequencies which are to be used, the audio oscillator is connected to the input terminals of the a-f channel to be tested. The oscillograph is connected across the output of this channel. The same procedure is followed again but at this time the a-f channel is being checked for frequency response. Any deviations from the deflection originally produced on the oscillograph should be noted. If these deviations are outside the limits set forth in the specification for the a-f channel, the a-f channel should be investigated to correct the trouble.

(2) Procedure—

Preliminary Settings

COARSE FREQUENCY	— between 30 and 150
SYNC SELECTOR	— INT
VERTICAL INPUT	— DIR

Step 1. Connect the output terminal of the audio oscillator to the VERTICAL INPUT terminal of the oscillograph and ground of the oscillator to GROUND of the oscillograph.

Step 2. Turn on the oscillograph and the audio oscillator and set the audio oscillator at the low frequency limit of the a-f channel of the transmitter.

Step 3. Synchronize several cycles of the sine wave and note deflection produced on the cathode-ray tube.

Step 4. Increase the frequency of the audio oscillator noting any deviation in the deflection produced on the cathode-ray oscillograph.

Step 5. Turn off the audio oscillator.

Step 6. Connect the output of the audio oscillator to the input terminals of the a-f channel of the transmitter.

Step 7. Connect the VERTICAL INPUT of the oscillograph to the output terminal of the a-f channel of the transmitter.

Step 8. Connect a common ground between all three units: the oscillograph, the a-f channel, and the audio oscillator.

Step 9. Turn on the a-f channel of the transmitter and the audio oscillator.

Step 10. Synchronize the same number of waves at the same amplitude as that used in Step 2 (adjust the output of the audio oscillator to result in the same vertical deflection).

Step 11. Increase the frequency of the audio oscillator to the upper limit of the a-f channel noting any change in amplitude of the pattern on the oscillograph.

Note

Since a low setting of the gain control on the oscillograph may attenuate the signal unevenly, the amplifier in the oscillograph is shunted in this procedure and the output of the a-f channel is capacitively coupled to the deflection plates.

(3) Trouble Shooting.—If the output signal is not comparable to the input from the audio oscillator, trouble within the a-f channel is indicated. To localize this trouble, the operator should remove the connection from the output terminal of the a-f channel and connect it to the input of the last stage. If the irregularity in the wave form clears up at this point, the trouble is localized to the amplifier output stage.

If the distortion still appears, the operator should continue working backwards through the channel until he finds the point where distortion is no longer in evidence. At this time, he can be assured that the circuit causing this distortion is the following stage and he should, therefore, check that stage carefully.

e. MONITORING THE TRANSMITTER OUTPUT.

(1) Introduction.—Once the transmitter is aligned and adjusted the oscillograph may be used as an indicator of the overall performance of the transmitter output signal, and as a modulation monitor.

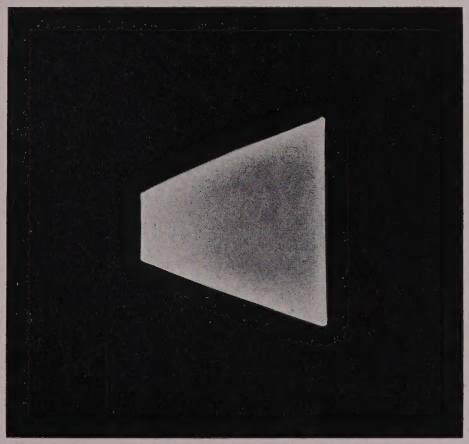


FIGURE 3-18
TRAPEZOIDAL MODULATION PATTERN

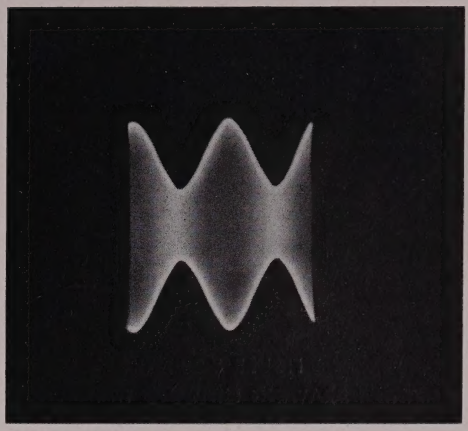


FIGURE 3-19
MODULATED CARRIER WAVE PATTERN

(2) Waveforms.—There are two types of patterns that can serve as indicators, the trapezoidal pattern (Figure 3-18) and the modulated wave pattern (Figure 3-19). The trapezoidal pattern is presented on the screen by impressing a modulated carrier wave signal on the vertical deflection plates and the signal that modulates the carrier wave signal (the modulating signal) on the horizontal deflection plates. The trapezoidal pattern can be analyzed by the method used previously in analyzing waveforms. Figure 3-20 shows how the signals cause the electron beam to trace out the pattern.

The modulated wave pattern is accomplished by presenting a modulated carrier wave on the vertical deflection plates and by using the time-base generator for horizontal deflection. The modulated wave pattern also can be analyzing waveforms. Figure 3-21 shows how the two signals cause the electron beam to trace out the pattern.

(3) Procedure for Obtaining the Trapezoidal Pattern.

Preliminary Settings

SYNC SELECTOR	— EXT
VERTICAL INPUT switch	— DIR
COARSE FREQUENCY	— HOR INPUT DIR

Step 1. Construct a monitor circuit in the output (modulator) stage of the a-f channel. The circuit in Figure 3-22 is satisfactory.

Step 2. Connect the output from the monitor circuit across HORIZONTAL INPUT and GROUND.

Step 3. Loosely couple a pick-up loop (see the preceding paragraph b. for description) to the modulated stage of the r-f channel of the transmitter.

Step 4. Connect the leads from the pick-up loop to VERTICAL INPUT and GROUND.

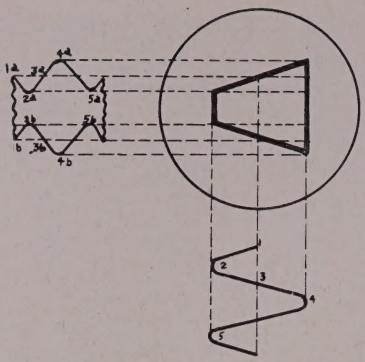


FIGURE 3-20
PROJECTION DRAWING SHOWING TRAPEZOIDAL PATTERN

Step 5. Using a sine wave oscillator for the a-f (modulating) signal, turn on the transmitter, sine wave oscillator and the oscillograph.

Step 6. If the vertical size of the pattern is inconveniently small refer to paragraph b. Step 5 for instructions.

Step 7. Control the size of the pattern on the vertical plane by adjusting the coupling and in the horizontal plane by adjusting the volume control in the monitor circuit (Figure 3-22).

(4) Procedure: Modulated Wave Pattern—

Preliminary Settings

SYNC AMP control	— 0
SYNC SELECTOR	— EXT
VERTICAL INPUT switch	— DIR

Step 1. Follow Steps 1 through 4 of the preceding paragraph.

Step 2. Remove the lead from the HORIZONTAL INPUT and place it on the EXT SYNC terminal.

Step 3. Set the COARSE FREQUENCY switch to include the frequency of the modulating sine wave signal.

Step 4. Set the HORIZONTAL AMP control to result in convenient horizontal deflection.

Step 5. Adjust the FINE FREQUENCY control to obtain 2 or 3 cycles of the modulating frequency on the screen of the cathode-ray tube.

Step 6. Add enough SYNC AMP to "lock-in" the pattern.

Remarks.—The trapezoidal and modulated wave patterns show a picture of the overall performance of the transmitter. By changing the degree of modulation of the carrier wave the shape of the pattern changes. Figures 3-23 through 3-28 show the trapezoidal and modulated wave patterns in various degrees of modulation.

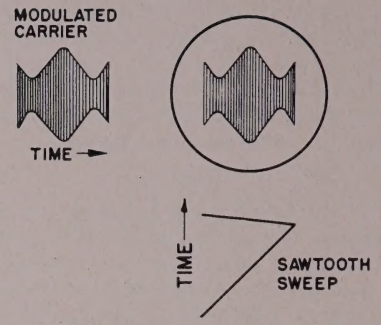


FIGURE 3-21
PROJECTION DRAWING SHOWING MODULATED CARRIER WAVE PATTERN

Modulation percentage may be determined by the following formula:

$$\text{Modulation percentage} = \frac{E_{max} - E_{min}}{E_{max} + E_{min}} \times 100$$

E_{max} and E_{min} are defined in Figures 3-23 and 3-24.

f. TROUBLE SHOOTING.

The trapezoidal and modulated wave patterns can serve as indicators for trouble shooting the transmitter. The method employed is to observe the pattern and note any distortion. Then the shape of the pattern reveals the position of the trouble. This method of trouble shooting requires a certain amount of experience, but proves to be highly satisfactory.

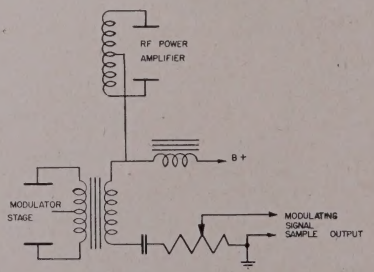


FIGURE 3-22
MONITOR CIRCUIT FOR THE MODULATING SIGNAL

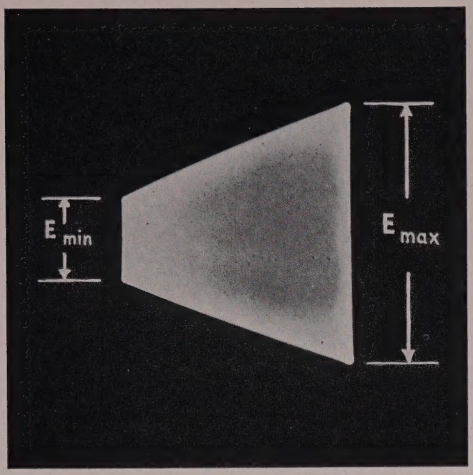


FIGURE 3-23
TRAPEZOIDAL WAVE PATTERN (LESS THAN 100% MODULATION)

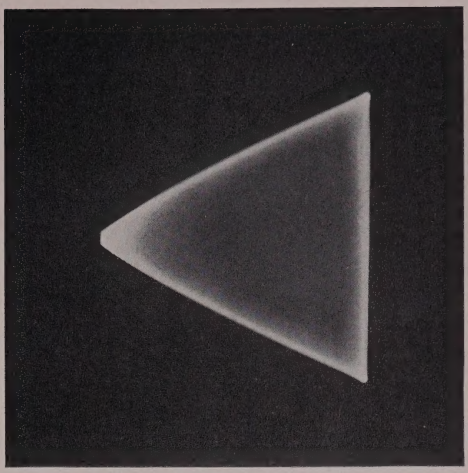


FIGURE 3-25
TRAPEZOIDAL WAVE PATTERN (100% MODULATION)

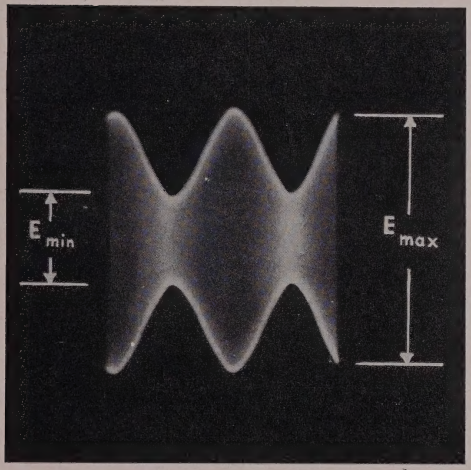


FIGURE 3-24
CARRIER WAVE PATTERN (LESS THAN 100% MODULATION)

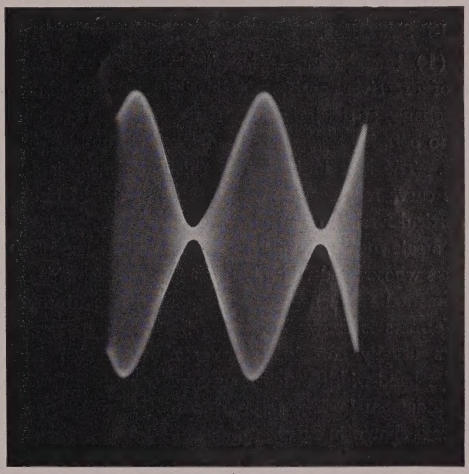


FIGURE 3-26
CARRIER WAVE PATTERN (100% MODULATION)

7. ALIGNING A-M RADIO RECEIVERS

a. INTRODUCTION.

To complete the discussion of the use of the oscillograph in aligning amplitude modulated radio systems there remains the subject of radio receivers. Included in receiver servicing is the adjustment of the radio frequency (r-f) and intermediate frequency (i-f), in superhetrodyne type radio receivers, and the servicing of audio frequency (a-f) amplifiers.

b. A-F AMPLIFIERS.

The object of the a-f amplifier of a receiver is to provide amplification for the detected signal which has uniform response throughout the desired frequency limits. The equipment necessary for checking audio amplifiers consists of: An audio oscillator of sine wave output in combination with an oscillograph. The procedure for checking an audio amplifier with a sine wave oscillator is identical with that used in checking the audio frequency channel of a transmitter as described earlier in this section.

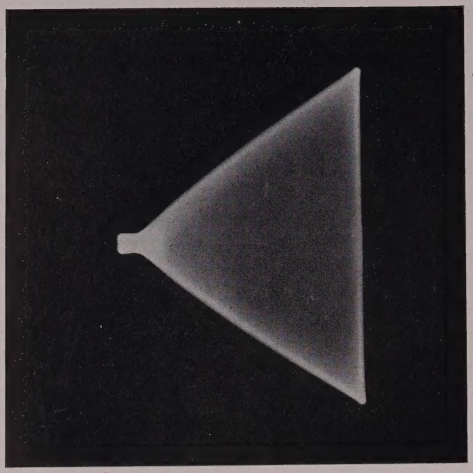


FIGURE 3-27
TRAPEZOIDAL WAVE PATTERN (OVER MODULATION)

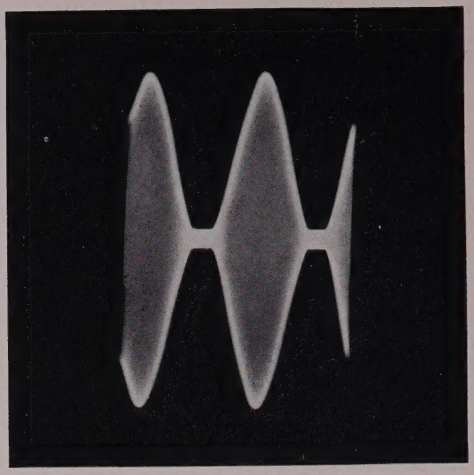


FIGURE 3-28
CARRIER WAVE PATTERN (OVER MODULATION)

c. I-F SYSTEMS.

(1) Introduction.—The alignment of the i-f amplifiers of a receiver consists of adjusting all the tuned circuits to resonance at the intermediate-frequency and at the same time to permit passage of a predetermined number of side bands. The best indication of this adjustment is a resonance curve representing the response of the i-f circuit to its particular range of frequencies.

As a rule medium and low-priced receivers use i-f transformers whose band-width is about 5 kc on each side of the fundamental frequency. The response curve of these i-f transformers is shown in Figure 3-29. High fidelity receivers usually contain i-f transformers which have a broader band-width which is usually 10 kc on each side of the fundamental. The response curve for this type transformer is shown in Figure 3-30.

Resonance curves such as these can be displayed on the screen of an oscillograph. For a complete understanding of the procedure it is important to know how the resonance curve is traced.

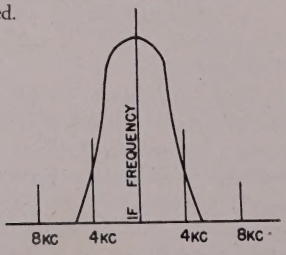


FIGURE 3-29
FREQUENCY RESPONSE CURVE OF THE I-F OF A LOW PRICED RECEIVER

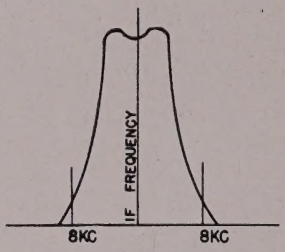


FIGURE 3-30
FREQUENCY RESPONSE CURVE OF HIGH-FIDELITY I-F STAGES

(2) The Resonance Curve on the Screen.—To present a resonance curve on the screen, a frequency-modulated signal source must be available. This signal source is a signal generator whose output is the fundamental i-f frequency which is frequency-modulated 5 to 10 kc each side of the fundamental frequency. A signal generator of this type generally takes the form of an ordinary signal generator with a rotating motor driven tuned circuit capacitor, called a wobulator, or its electronic equivalent, a reactance tube.

The method of presenting a resonance curve on the screen is to connect the vertical channel of the oscillograph across the detector (demodulator) load of the receiver as shown in the detectors of Figure 3-31 (between point A and ground) and the time-base generator output to the horizontal channel. In this way the d-c voltage across the detector load varies with the frequencies which are passed by the i-f system. Thus, if the time-base generator is set

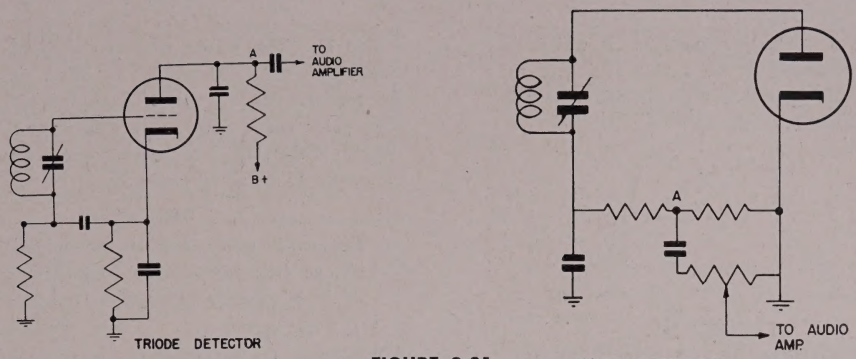


FIGURE 3-31 DIODE DETECTOR
CONNECTION OF THE OSCILLOGRAPH ACROSS THE DETECTOR LOAD

at the frequency of rotation of the motor driven capacitor, or the reactance tube, a pattern resembling Figure 3-32, a double resonance curve, appears on the screen.

Figure 3-32 is explained by considering Figure 3-33. In half a rotation of the motor driven capacitor the frequency increases from 445 kc to 465 kc, more than covering the range of frequencies passed by the i-f system. Therefore, a full resonance curve is presented on the screen during this half cycle of rotation since only *half* a cycle of the voltage producing horizontal deflection has transpired. In the second half of the rotation the motor driven capacitor takes the frequency of the signal in the reverse order through the range of frequencies passed by the i-f system. In this interval the time-base generator sawtooth waveform completes its cycle, drawing the electron beam further across the screen and then returning it to the starting point. Subsequent cycles of the motor driven capacitor and the sawtooth voltage merely retrace the same pattern. Since the signal being viewed is applied through the vertical amplifier, the sweep can be synchronized internally.

Some signal generators, particularly those employing a reactance tube, provide a sweep output in the form of a sine wave which is synchronized to the frequency with which the reactance tube is swinging the fundamental frequency through its limits, usually 60 cycles per second. If such a signal is used for horizontal deflection, it is already synchronized. Since this signal is a sine wave, the response curve is observed as it sweeps the spot across the screen from left to right; and it is observed again as the sine wave sweeps the spot back again from right to left. Under these conditions the two response curves are superimposed on each other and the high frequency responses of both curves are at one end and the low frequency response of both curves is at the other end. The i-f trimmer capacitors are adjusted to produce a response curve which is symmetrical on each side of the fundamental frequency.

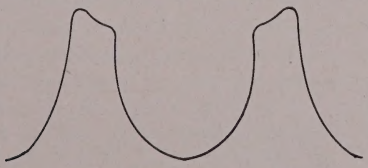


FIGURE 3-32
DOUBLE RESONANCE CURVE

When using sawtooth sweep, the two response curves can also be superimposed. If the sawtooth signal is generated at exactly twice the frequency of rotation of the motor driven capacitor, the two resonance curves will be superimposed (Figure 3-34) if the i-f transformers are properly tuned. If the two curves do not coincide the i-f trimmer capacitors should be adjusted. At the point of coincidence the tuning is correct. It should be pointed out that rarely do the two curves agree perfectly. As a result, optimum adjustment is made by making the peaks coincide. This latter procedure is the one generally used in i-f adjustment. When the two curves coincide, it is evident that the i-f system responds equally to signals higher and lower than the fundamental i-f frequency.

Note

Before correcting the setting of the trimmer capacitors, it is necessary to adjust the FINE FREQUENCY control to make the two peaks of the frequency response curves coincide. After these two curves are thus superimposed, the operator should then proceed with the adjustment of the trimmer capacitors to achieve coincidence of the

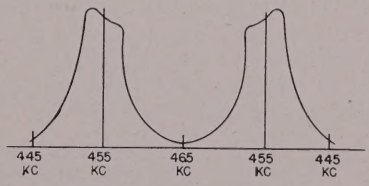


FIGURE 3-33
DOUBLE RESONANCE ACHIEVED BY COMPLETE ROTATION OF THE MOTOR DRIVEN CAPACITOR

two curves as nearly as possible. It will probably be necessary to use a high setting of the SYNC AMP control to maintain this pattern in synchronization.

FIGURE 3-34
SUPER-POSITION OF RESONANCE CURVES

(3) Procedure.—Since most i-f systems contain several stages the number of variables must be decreased by starting the alignment at the last i-f circuit and working backward from the detector.

Preliminary Settings

SYNC SELECTOR — INT
VERTICAL INPUT — AMP

Step 1. Join the antenna and ground connections of the receiver together with a 0.001 mfd. capacitor.

Step 2. Short out the tank circuit of the receiver beat frequency oscillator with a wire lead connecting the rotor and stator of its variable capacitor (steps 1 and 2 prevent unwanted signals from entering the i-f system).

Step 3. Connect the output of the frequency-modulated signal generator between grid and ground of the last i-f amplifier tube.

Step 4. Connect VERTICAL INPUT and GROUND across the detector load impedance (Figure 3-31).

Step 5. Set the frequency dial of the frequency-modulated signal generator to the intermediate-frequency to be passed by the i-f system.

Step 6. Turn on the signal generator, oscillograph, and radio receiver.

Step 7. Assuming that the time-base generator of the oscillograph is used, set COARSE FREQUENCY to include twice the frequency of rotation of the motor driven capacitor (or the reactance tube) and adjust the FINE FREQUENCY and SYNC AMP controls to obtain stationary superimposed resonance curves.

Step 8. Adjust HORIZONTAL AMP and VERTICAL AMP CONTROLS for a conveniently sized pattern.

Step 9. Adjust the i-f trimmer capacitors in the plate circuits of this i-f stage until the two response curves are superimposed on each other.

Step 10. Move the input of the signal generator from the grid of this tube to the grid of the preceding i-f amplifier. (On small receivers having only one i-f tube, the signal is placed on the grid of the mixer or the converter tube.)

Step 11. Turn on the receiver and adjust the trimmer capacitors in the i-f transformer for this stage as in Step 9. The receiver output to the oscillograph is still taken at the same point, across the detector load resistor. Because of the gain of this stage, it will probably be necessary to reduce the output of the signal generator.

CAUTION

Once an i-f transformer has been aligned, do not change the setting of its i-f trimmer capacitors, or the alignment will have been changed.

d. R-F SECTION.

Following the alignment of the i-f amplifiers in the superhetrodyne receiver, the next section of the circuit to be adjusted is the r-f section.

(1) Introduction.—The main objects in aligning the r-f systems of a receiver are: (1) to adjust the r-f tank circuits to resonance at the frequency indicated by the receiver dial setting and, (2) to adjust tank circuit of the local oscillator in the receiver to resonance at the frequency indicated by the dial setting *plus* the intermediate frequency of the receiver.

(2) Equipment.—Together with the oscillograph, the necessary equipment is a frequency-modulated signal generator, similar to the one used in aligning i-f systems.

(3) Operation.—As in i-f alignment, the r-f signal is fed into the circuit under examination and the response of that circuit tested by observing the signal voltage across the receiver detector load. The r-f stages are in alignment when the normal i-f response curve is at maximum amplitude.

(4) Aligning the R-F Section.—For r-f alignment the frequency modulated signal is capacitively coupled into the antenna. Both the signal generator and the receiver dial are set for the same fundamental frequency approximately 650 kc. The local oscillator padding capacitor is then tuned to result in the correct i-f frequency. The i-f curve which appears on the screen of the cathode-ray tube varies in amplitude as the local oscillator is tuned. Correct tuning is indicated by maximum amplitude of the i-f response curve.

The signal generator and the receiver dial are both set at the same high fundamental frequency, approximately 1400 kc. The trimmer capacitor, in parallel with the local oscillator tuning capacitor, is then adjusted to result in the maximum amplitude of the i-f frequency response curve.

This procedure of adjusting the dial at approximately 1/4 maximum and 1/4 minimum range insures reasonably good tracking of the oscillator over the entire broadcast band. Of course, the adjustment of the high end after that of the low end requires a resetting of the low end again. These two settings affect each other and they are balanced as closely as possible after two or three settings.

After the oscillator has been aligned, the final step in aligning the r-f section is the trimmer capacitor on the r-f tuning capacitor. This is adjusted to the optimum setting for maximum amplitude of the i-f response curve over the entire band. This capacitor will naturally have more effect on the high frequency than that on the low frequency end of the band. Sets having one or more r-f stages have other trimmers on their tuning capacitors which should be adjusted similarly. The alignment of receivers with the oscillograph permits the serviceman to observe the overall performance of the receiver.

(5) Procedure.

Step 1. Connect the oscillograph across the detector load resistor as explained in the alignment of i-f circuits.

Step 2. Set the receiver tuning dial at approximately 650 kc.

Step 3. Set the fundamental frequency of the f-m signal generator to 650 kc.

Step 4. Connect the output of the signal generator through a capacitor of about 1000 $\mu\mu$f to the antenna terminal and ground of the signal generator to ground of the receiver. (Naturally the capacitor connected between the antenna and ground and the shorting wire across the receiver oscillator capacitor should be removed. These special connections were made for i-f alignment only.)

Step 5. Turn on the signal generator, the receiver, and the oscillograph.

Step 6. Adjust the local oscillator padder capacitor (in some cases the oscillator inductance) to obtain the maximum amplitude of the i-f response curve which appears on the oscillograph.

Step 7. Set the receiver tuning dial at 1400 kc and the fundamental frequency of the signal generator also at 1400 kc.

Step 8. Adjust the trimmer capacitor in parallel with the oscillator tuning capacitor to result in maximum amplitude of the i-f response curve.

Step 9. Then turn to the settings for aligning the low frequency end of the dial and adjust the oscillator padder capacitor again to result in maximum amplitude.

Step 10. Return to the high frequency position on the dial and adjust the trimmer capacitor again to maximum amplitude.

Note

Probably two or three settings at both of these points will determine the optimum setting for good tracking over the entire band.

Step 11. A final check of tracking is determined by checking the amplitude of the i-f response curve at about 1000 kc. If this amplitude is approximately the same as that at each of the other two settings, good tracking is practically assured.

Step 12. After the oscillator has been aligned for tracking, the trimmer capacitor in parallel with the r-f tuning capacitor should be adjusted to result in optimum amplitude of the i-f response curve throughout the dial range.

Note

In the cheaper models of the a-c—d-c sets it is extremely difficult to align the receiver by this method because 60-cycle pick-up is prevalent throughout the chassis with practically the entire receiver operating above ground potential. Such prevalence of 60-cycle pick-up may make it very awkward to align a receiver by this method. In this case it is possible to capacitively couple the incoming signal to the antenna with a very small capacitor. The output to the oscillograph is taken across the two terminals of the speaker coil. The i-f signal is fed into the antenna with the local oscillator shorted out while the i-f amplifiers are being adjusted. This shunt should then be removed for the alignment of the r-f section.

8. ALIGNING F-M RADIO RECEIVERS

a. INTRODUCTION.

(1) Purpose of F-M.—The narrow channel permitted a-m broadcasting limits the modulating signal to the lower audio frequencies, but with a top audio frequency of 15,000 cycles, f-m broadcasting adds overtones and thus more perfect reproductions to music and speech. Therefore, f-m receivers are designed to offer listeners an output signal of higher fidelity than is possible with a-m receivers. To achieve this high fidelity, f-m is operated with broad channels on a high frequency band.

(2) F-M vs. A-M.—The essential difference between f-m and a-m receivers lies in the method of detection. An a-m detector receives an r-f signal, amplitude modulated at an audio rate, strips off the r-f carrier, and delivers the audio signal to the audio amplifiers. An f-m detector receives a very high frequency, (v.h.f) signal, frequency modulated at an audio rate, removes the v.h.f. carrier, and delivers an audio signal, directly proportional to the amount of frequency modulation, to the audio amplifiers. The f-m circuit comparable to the a-m detector is called the discriminator.

The equipment necessary for f-m receiver alignment is an oscillograph and a frequency modulated signal generator, similar to the equipment required in a-m receiver servicing. Also, in f-m servicing the nature of the system demands that the signal generator frequency be in the f-m range and frequency modulated over a 200 kc band.

Aligning the i-f amplifiers of f-m receivers with an oscillograph is similar to the procedure for a-m except that all

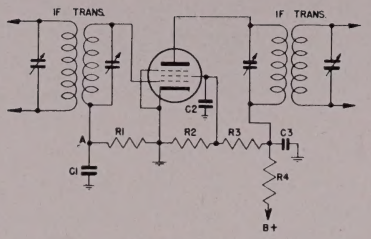


FIGURE 3-35
OSCILLOGRAPH CONNECTION TO OBTAIN I-F CURVE IN F-M RECEIVERS

f-m amplifiers are high fidelity circuits and therefore have broad-band i-f transformers resulting in a broad-band i-f response curve.

b. I-F and R-F ALIGNMENT.

(1) Procedure.—The procedure for aligning the i-f and r-f sections of an f-m receiver is identical with that of aligning the a-m receiver except that the oscillograph is connected to a different section of the circuit and the frequencies are much higher.

(2) Connecting the Oscillograph.—The oscillograph is connected across the grid resistor R1 of the first limiter stage as shown in Figure 3-35. If the load across this resistor is used for a.v.c., however, it is necessary to remove the connections from one of the cathodes of the discriminator as shown in Figure 3-36. This results in the discriminator becoming an a-m detector and the oscillograph is connected across the diode load which is still connected in the circuit. The transformer in the discriminator stage then must be tuned first as a regular i-f transformer.

c. DISCRIMINATOR ALIGNMENT.

(1) General.—There are several f-m discriminator circuits, but they all depend on approximately the same output circuit to the audio stages. This output has opposite polarity for frequencies on either side of resonance of the discriminator tank circuit and becomes greater in amplitude with deviation from the resonant frequency up to a certain point. Diagrammatically, Figure 3-37 shows a characteristic curve of a typical discriminator. Then, on the screen of the oscillograph, with a complete cycle of the output from the frequency modulated signal generator, two curves similar to the one shown in Figure 3-37 result if the time base of the oscillograph is set at the frequency of the rotating capacitor. If, however, the time-base is set to twice the frequency of the output cycle from the signal generator, a pattern resembling Figure 3-38 can be obtained. This latter type pattern is the one generally used in discriminator servicing.

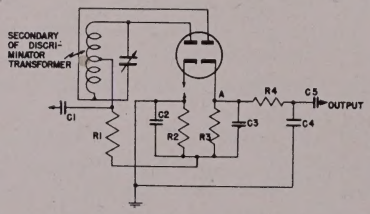


FIGURE 3-36
ALTERNATE METHOD OF OBTAINING I-F CURVE IN F-M RECEIVERS

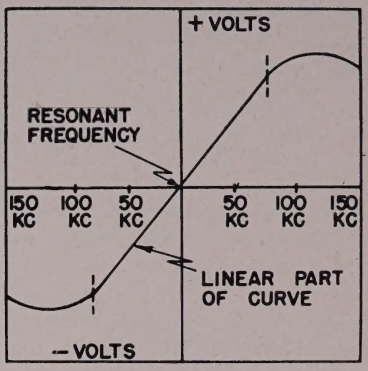


FIGURE 3-37
CHARACTERISTIC DISCRIMINATOR CURVE

(2) Factors Affecting Correct Adjustment.—The primary and secondary of the discriminator transformer generally contain parallel trimmer condensers which can be adjusted. In most cases the primary trimmer affects the symmetry of the pattern and the secondary trimmer the position where the curves cross. It must be remembered

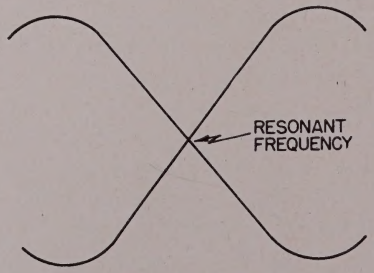


FIGURE 3-38
SUPER-IMPOSED DISCRIMINATOR CURVES

that if the cross-over point of the two curves is not at the center of the pattern, the circuit is not tuned to the correct resonant frequency.

(3) Procedure.

Step 1. Reconnect R2 and C2 into the discriminator circuit if they were removed for i-f alignment.

Step 2. Connect the oscillograph between grid and ground of the first audio stage.

Step 3. If the alignment of the i-f and r-f sections of the circuit has already been performed, the input signal may be fed into the antenna. However, if the preceding circuits have not been aligned, the input signal should be connected between grid and ground of the limiter stage preceding the discriminator.

Step 4. Obtain a pattern which is symmetrical and approaches as closely as possible that shown in Figure 3-37.

SECTION IV

MAINTENANCE

1. GENERAL

The components used in the Type 274-A Cathode-ray Oscillograph have been selected and tested to provide long, trouble-free operating life. It must be recognized, however, that trouble may be expected at some time during the life of the instrument. This section is included to provide useful information for the location and correction of such trouble.

2. DRAWINGS

The schematics of the circuits located just inside of the back cover give the complete information as to how the various components are connected. A list of parts with their descriptions is given on the page accompanying the schematic diagrams.

WARNING

DANGEROUS POTENTIALS AS HIGH AS 1200 VOLTS ARE FOUND IN THIS INSTRUMENT. SINCE THESE POTENTIALS MAY BE DANGEROUS TO HUMAN LIFE, THEY SHOULD BE TREATED WITH PROPER CAUTION.

3. CIRCUIT VOLTAGES

Table 4-1 is included to give the voltages and resistances that are found between the socket connections of the various tubes and ground. The meter used for these measurements has an internal resistance of 20,000 ohms per volt. Naturally voltages or resistance measurements taken with a meter having a lower internal resistance will differ from the values of this table.

It should be remembered that the values given are nominal and considerable variation may be experienced due to various line voltage conditions and component tolerances. Generally, a variation of $\pm 10\%$ is to be expected and 20% may not be uncommon. Judgment is often required to determine if a particular deviation is indicative of trouble.

4. WARRANTY

DU MONT INSTRUMENTS.

All instruments manufactured by Allen B. Du Mont Laboratories, Inc., are guaranteed to equal or exceed all specifications for that particular instrument as published by the company. They are further guaranteed against defective materials, other than the cathode-ray tube, and workmanship for a period of one year from date of sale, and we will promptly repair the instrument or replace it, at our discretion, at any time within the guarantee period should any defect develop from these causes or the instrument be not as represented, upon our inspection of the equipment.

In order that this guarantee be effective, it is necessary that the enclosed guarantee card be properly filled out and mailed to the factory immediately upon receipt of the equipment. Complete information should be given, since a record of every instrument is maintained at our office. This record constitutes our source of information when any correspondence is necessary. Both the *type number and the serial number* of the instrument must be given on this card in order that the information be complete.

DU MONT CATHODE-RAY TUBES.

All industrial cathode-ray tubes manufactured and sold by Allen B. Du Mont Laboratories are guaranteed for a life of 1,000 hours or for six months, depending upon which expires first. The only exceptions to this guarantee are burned-out heaters and broken glass. Cathode-ray tubes will be promptly replaced within the guarantee period if, upon our inspection, the tube has failed within less than its normal expected life.

In order that this guarantee be effective, it is necessary that the enclosed gaurantee card be properly filled out and mailed to the factory immediately upon receipt of the equipment. Complete information should be given in order that the records which we maintain on your particular tube will be accurate. When correspondence is necessary, both *type number and serial number* of the tube should be mentioned. The serial number of Du Mont cathode-ray tubes will be found on the glass stem of the electron gun.

5. SERVICE

Du Mont equipment is designed and manufactured in accordance with the best practices of modern engineering, and it is fully inspected before it leaves our factory. Under normal operation it may be expected to give long, trouble-free service. In order to insure factory service and proper consideration within the guarantee period, the enclosed guarantee card should be properly filled out and mailed to the factory immediately upon receipt of the equipment.

In many cases, equipment has been returned to us, without authorization, and without any need for our examina-

tion, resulting in unnecessary shipping costs. In the event that you feel you have not received satisfactory operation from this equipment, you should immediately contact our Instrument Service Department, mentioning the *type number and serial number,* completely outlining all characteristics of the failure, and describing the method in which the equipment has been used.

It is important that such information be given, since much time often can be saved when all operating conditions are known. With such information we often are able to make decisions and suggestions which will avoid returning it to our plant. The foregoing applies also to Du Mont cathode-ray tubes.

All equipment returned to our plant should be shipped, carefully packed, via express prepaid. Cathode-ray tubes larger than five inches screen diameter should be shipped separately and should not be left mounted in their socket within the instrument. In addition, all equipment should be properly identified either by a packing slip or, preferably, by a suitable tag affixed to it. Unidentified equipment which has been returned to us is a serious source of needless errors and delays.

6. REPLACEMENT PARTS

When ordering replacement parts, always give the *type number and serial number* of the instrument and refer to the part by its symbol designation and its description on the schematic.

7. SPECIFICATIONS

The right is reserved to change the specifications of any equipment, without notice, at any time. This right shall not incur any liability to Allen B. Du Mont Laboratories, Inc., to change equipment previously sold, or to supply new equipment in accordance with earlier specifications.

THE DU MONT "OSCILLOGRAPHER"

The Du Mont "Oscillographer," a quarterly publication, is published regularly by the Allen B. Du Mont Laboratories. It is sent free of charge to engineers, research workers, and those engaged in the use and application of cathode-ray equipment. When sending requests for subscriptions and address-change notice, please supply the following: name, company name, company address, type of business, and title of individual.

WARNING

EXERCISE EXTREME CARE WHEN HANDLING THE CATHODE-RAY TUBE. IT MAY BE SCRATCHED AND THEREBY WEAKENED TO THE POINT WHERE IT MAY EASILY BE BROKEN. THE BREAKING OF THIS TUBE MAY CAUSE AN IMPLOSION AND RESULT IN PERSONAL INJURY FROM FLYING GLASS PARTICLES.

TABLE OF VOLTAGE AND RESISTANCE

K=1000 OHMS

Pin No.	*Resistance to Ground in Ohms*	*D-C Voltage to Ground*	*Control Affecting Reading*
	V-1 Type 6AC7—Vertical Amplifier		
1	0	0	
2	0	0	
3	IK	2.4	
4	0 to 1 meg.	0	VERTICAL AMP
5	IK	2.4	
6	48K	70	
7	0.6 ohm	6.3 ac	
8	200K	210	
	V-2 Type 6AC7—Horizontal Amplifier		
1	0	0	
2	0	0	
3	IK	2.4	
4	0 to 1 meg.	0	HORIZONTAL AMP
5	1K	2.4	
6	48K	70	
7	0.6 ohm	6.3 ac	
8	200K	190-215	COARSE AND FINE FREQUENCY CONTROL
	V-3 Type 884—Sweep Generator		
1	0 to 100K (only SYNC. Amp.)	0-2.5	FINE AND COARSE FREQUENCY AND SYNC AMP
2	0	0	
3	500K to 5 meg.	7.5-45	FINE AND COARSE FREQUENCY
4	NC	NC	
5	10K to 110K (only SYNC. Amp.)	0-0.24	SYNC AMP
6	NC	NC	
7	0.6	6.3 ac	
8	1.3K	5.6-6.2	FINE FREQUENCY CONTROL
	V-4 Type 80—High Voltage Rectifier		
1	3K	1000 ac	
2	2 meg.	—1500	
3	2 meg.	—1500	
4	3K	1000 ac	
	V-5 Type 80—Low Voltage Rectifier		
1	100K	480	
2	540 ohms	380 ac	
3	540 ohms	380 ac	
4	100K	480	
	V-6 Type 5BP-A—Cathode-Ray Tube		
1	1.5 meg.	—1100	
2	NC	NC	
3	5 meg.	+75 to —75	HORIZONTAL POSITIONING
4	700K to 1 meg.	—600 to —900	FOCUS
5	NC	NC	
6	5 meg.	+75 to —75	VERTICAL POSITIONING
7	0	0	
8	0	0	
9	0	0	
10	2 meg.	—1100	
11	1.5 meg.	—1100	INTENSITY CONTROL

PATENT NOTICE

Manufactured under one or more of the following U. S. Patents:

1,844,117	1,960,333	1,999,407	2,000,014	2,014,106
2,067,382	2,082,327	2,085,576	2,087,280	2,098,231
2,153,800	2,157,749	2,162,009	2,163,256	2,164,176
2,185,705	2,186,634	2,186,635	2,190,020	RE. 21,326
2,201,309	2,207,048	2,208,254	2,209,507	2,221,398
2,225,099	2,227,822	2,229,556	2,245,409	2,245,428
2,249,942	2,249,943	2,269,115	2,269,129	2,280,700
2,280,738	2,290,592	2,297,742	2,297,752	2,299,471
2,299,510	2,315,848	2,319,691	2,321,149	2,328,259
2,331,401	2,337,980	2,338,336	2,338,646	2,343,630
2,345,549	2,346,509	2,347,933	2,355,363	2,356,733
2,364,687	2,365,476	2,372,455	2,372,901	2,373,114
2,379,488	2,384,931	2,389,025	2,391,082	2,391,090
2,391,273	DES. 143,796	2,396,014	2,398,535	2,398,959
2,404,185	2,408,193	2,409,419	2,410,920	2,414,319
2,414,634	2,419,118	2,419,177	2,423,362	2,426,419
2,429,824	2,435,564	2,435,680	2,436,265	2,437,173
2,438,668	2,438,706	2,438,717	2,439,186	2,440,597
2,441,334	2,442,138	2,442,264	2,442,545	

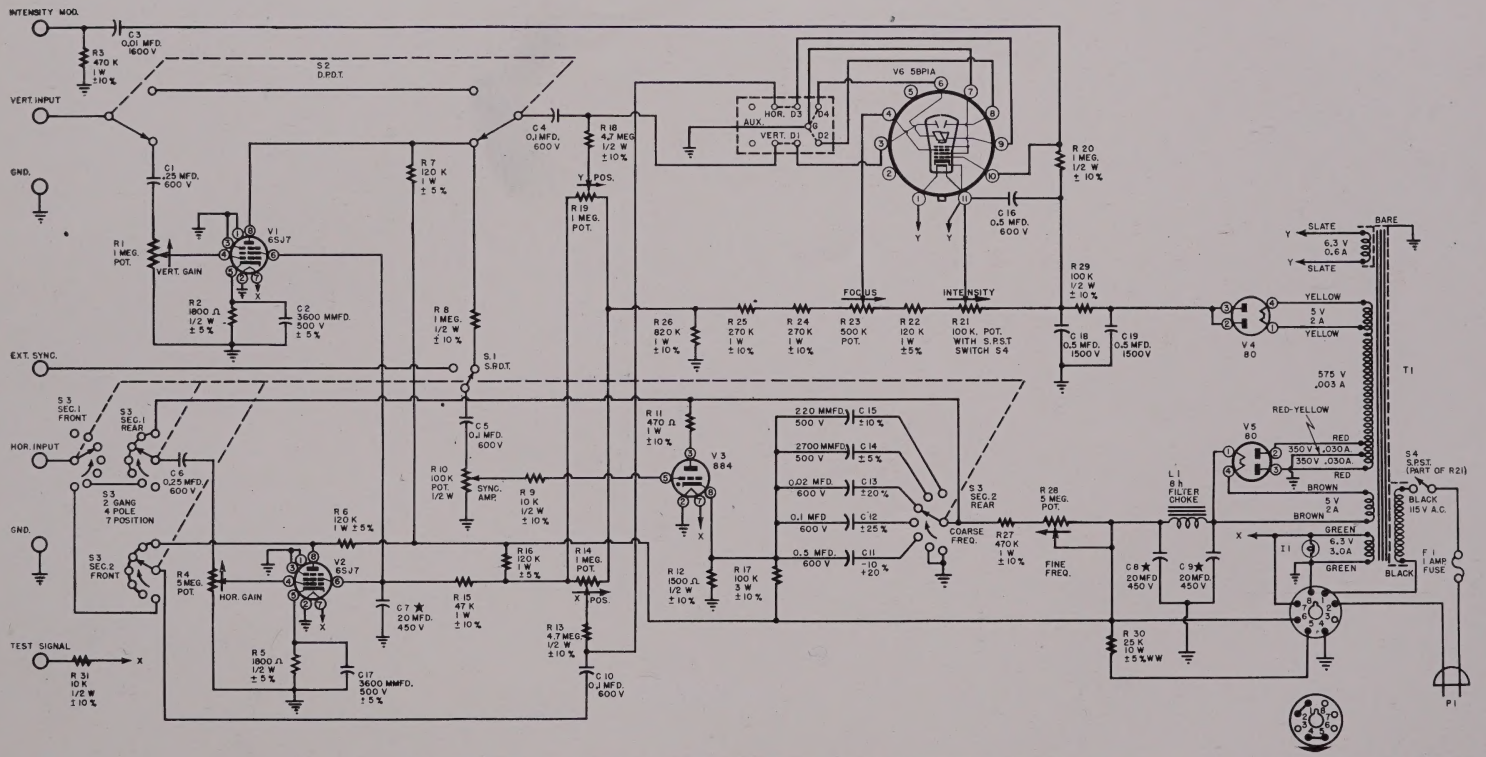
Other Patents Pending

ALLEN B. DU MONT LABORATORIES, INC.

CLIFTON, N. J., U. S. A.

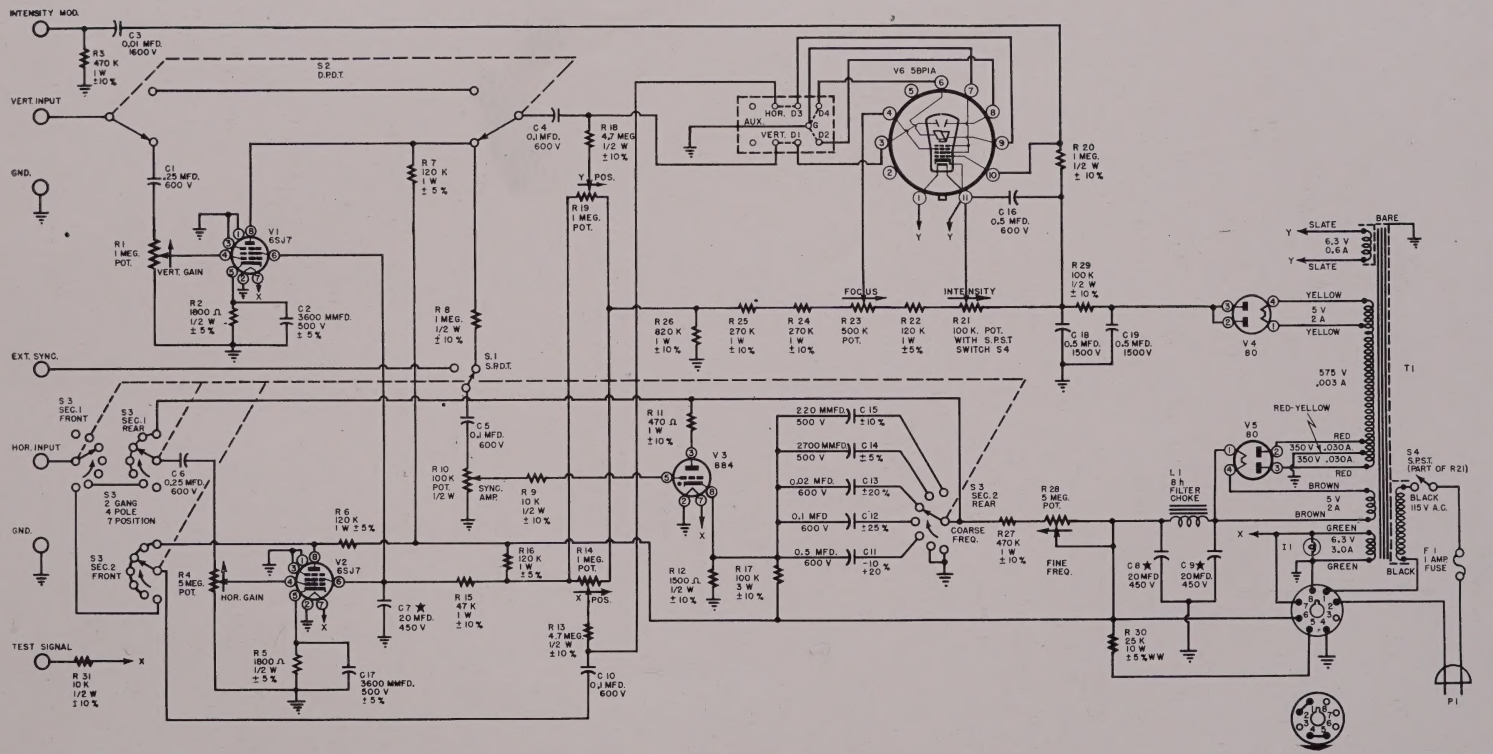
PARTS LIST—TYPE 274

SYMBOL DESIGNATION	REFERENCE DRAWING OR PART NO.	DESCRIPTION
C1	3-152	CAPACITOR, fixed: paper; wax; 0.25 mfd; 600 V; +30–10%
C2	CM35B362J	CAPACITOR, fixed: mica; 3600 mmfd; 500 V; ±5%
C3	3-1140	CAPACITOR, fixed: paper; wax; 0.01 mfd; 1600 V; + 30–10%
C4	3-1195	CAPACITOR, fixed: paper; wax; 0.1 mfd; 600 V; +30–10%
C5		Same as C4
C6		Same as C1
C7	3-1160	CAPACITOR, fixed: electrolytic; 20+20+20 mfd; 450 V
C8		Part of C7
C9		Part of C7
C10		Same as C4
C11	3-1082	CAPACITOR, fixed: paper; wax; 0.5 mfd; 600 V; +20–10%
C12	3-1138	CAPACITOR, fixed: paper; wax; 0.1 mfd; 600 V; ±25%
C13	3-1139	CAPACITOR, fixed: paper; wax; 0.02 mfd; 600 V; ±20%
C14	CM30B272J	CAPACITOR, fixed: mica; 2700 mmfd; 500 V; ±5%
C15	CM20B221K	CAPACITOR, fixed: mica; 220 mmfd; 500 V; ±10%
C16		Same as C11
C17		Same asC2
C18	3-360	CAPACITOR, fixed: paper; 0.5 mfd; 1500 V; +20–10%
C19		Same as C18
F1	11-3	FUSE, cartridge: 1 amp.
I1	39-4	LAMP, incandescent: miniature bayonet base
L1	21-338	INDUCTOR, fixed: filter; 8 hy.
P1	46-108	CABLE, power: copper; 2 #18 ga. stranded conductors; w/2 prong male plug one end
P2	9-294	CONNECTOR, male contact: 8 pin
R1	1-287	RESISTOR, variable: composition; 1 megohm; 1/2 W; ±20%
R2	RC21BF182J	RESISTOR, fixed: composition; 1800 ohm; 1/2 W; ±5%
R3	RC31BF474K	RESISTOR, fixed: composition; 470,000 ohm; 1 W; ±10%
R4	1-421	RESISTOR, variable: coposition; 5 megohm; 2 W; ±20%
R5		Same as R2
R6	RC31BF124J	RESISTOR, fixed: composition; 120,000 ohm; 1 W; ±5%
R7		Same as R6
R8	RC21BF105K	RESISTOR, fixed: composition; 1 megohm; 1/2 W; ±10%
R9	RC21BF103K	RESISTOR, fixed: composition; 10,000 ohm; 1/2 W; ±10%
R10	1-388	RESISTOR, variable: composition; 100,000 ohm; 1/2 W; ±20%
R11	RC31BF471K	RESISTOR, fixed: composition; 470 ohm; 1 W; ±10%
R12	RC21BF152K	RESISTOR, fixed: composition; 1500 ohms; 1/2 W; ±10%
R13	RC21BF475K	RESISTOR, fixed: composition; 4.7 meghom; 1/2 W; ±10%
R14		Same as R1
R15	RC31BF473K	RESISTOR, fixed: composition; 47,000 ohm; 1 W; ±10%
R16		Same as R6
R17	2-257	RESISTOR, fixed: composition; 100,000 ohm; 3 W; ±10%
R18		Same as R13
R19		Same as R1
R20		Same as R8
R21	1-463	RESISTOR, variable: composition; 100,000 ohm; 1/2 W; ±20%; with SPST switch S4
R22		Same as R6
R23	1-288	RESISTOR, variable: composition; 500,000 ohm; 1/2 W; ±20%
R24	RC31BF274K	RESISTOR, fixed: composition; 270,000 ohm; 1 W; ±10%
R25		Same as R24
R26	RC31BF824K	RESISTOR, fixed: composition; 820,000 ohm; 1 W; ±10%
R27		Same as R3
R28		Same as R4
R29	RC21BF104K	RESISTOR, fixed: composition; 100,000 ohm; 1/2 W; ±10%
R30	2-8	RESISTOR, fixed: wire wound; 25,000 ohm; 10 W; ±5%
R31		Same as R9
S1	5-10	SWITCH, toggle: SPDT
S2	5-12	SWITCH, toggle: DPDT
S3	5B-4647	SWITCH, 2 gang 4 pole: 7 pos. (formerly 5-198)
S4		Part of R21
T1	20D-4641	TRANSFORMER, plate and filament: (formerly 20-329)
V1	25-6SJ7	TUBE, electron: Triple-grid detector amplifier
V2		Same as V1
V3	25-884	TUBE, electron: Thyraton
V4	25-80	TUBE, electron: Full wave high-vacuum rectifier
V5		Same as V4
V6	25-5BP1A	TUBE, electron: Cathode-Ray



SCHEMATIC OF CIRCUIT. TYPE 274 CATHODE-RAY OSCILLOGRAPH

Ref. Dwg. DD-4652-C
Issue 5



SCHEMATIC OF CIRCUIT. TYPE 274 CATHODE-RAY OSCILLOGRAPH

Ref. Dwg. DD-4652-C
Issue 5

COMPONENTS PARTS LIST
TYPE 274-A CATHODE-RAY OSCILLOGRAPH

CAPACITORS

Symbol	Part No.	Description
C1	03001520/3–152	.25 μf 600 V paper
C2	03033350/CM35B512J	5100 μμf 500 V ±5% mica
C3	03011400/3–1140	.01 μf 1600 V paper
C4	03011950/3–1195	.1 μf 600 V paper
C5	03011950/3–1195	.1 μf 600 V paper
C6	03001520/3–152	.25 μf 600 V paper
C7	03011600/3–1160	20/20/20 μf 450 V elec.
C8	03033370/CM35B622J	6200 μμf 500 V ±5% mica
C9	03011950/3–1195	.1 μf 600 V paper
C10	03010820/3–1082	.5 μf 600 V paper
C11	03011380/3–1138	.1 μf 600 V paper
C12	03011390/3–1139	.02 μf 600 V paper
C13	03029340/CM30B272J	2700 μμf 500 V ±5% mica
C14	03020470/CM20B221K	220 μμf 500 V ±10% mica
C15	03003600/3–360	.5 μf 1500 V paper
C16	03003600/3–360	.5 μf 1500 V paper
C17	03010820/3–1082	.5 μf 600 V paper
C20	03007790/3–779	1.5/7 μμf 500 V var ceramic

FUSES

F1	11000760/11–3	1 amp

LAMPS

I1	12000840/39–4	.25 amp

INDUCTORS

L1	21003380/21–338	8 hy filter

RESISTORS

R1	01011120/1–287	1 meg ±20% 1/2 W var
R2	02030480/RC20BF102J	1000 ±5% 1/2 W
R3	02035090/RC30BF474K	470,000 ±10% 1 W
R4	01011120/1–287	1 meg ±20% 1/2 W var
R5	02030480/RC20BF102J	1000 ±5% 1/2 W
R6	02034000/RC30BF154J	150,000 ±5% 1 W
R7	02034000/RC30BF154J	150,000 ±5% 1 W
R8	02032130/RC20BF105K	1 meg ±10% 1/2 W
R9	02031890/RC20BF103K	10,000 ±10% 1/2 W
R10	01011080/1–388	100,000 ±20% 1/2 W var
R11	02034730/RC30BF471K	470 ±10% 1 W
R12	02031760/RC20BF821K	1300 ±5% 1/2 W
R13	02032210/RC20BF475K	4.7 meg ±10% 1/2 W
R14	01011120/1–287	1 meg ±20% 1/2 W var
R15	02034970/RC30BF473K	47,000 ±10% 1 W
R16	02033960/RC30BF104J	100,000 ±5% 1 W
R17	02071540/2–257	100,000 ±10% 3 W
R18	02032210/RC20BF475K	4.7 meg ±10% 1/2 W
R19	01011120/1–287	1 meg ±20% 1/2 W var
R20	02032130/RC20BF105K	1 meg ±10% 1/2 W
R21	01014600/1–463	100,000 ±20% 1/2 W var
R22	02035020/RC30BF124K	120,000 ±10% 1 W
R23	01011110/1–288	500,000 ±20% 1/2 W var
R24	02035040/RC30BF184K	180,000 ±10% 1 W
R25	02035040/RC30BF184K	180,000 ±10% 1 W
R26	02035120/RC30BF824K	820,000 ±10% 1 W
R27	02035090/RC30BF474K	470,000 ±10% 1 W
R28	01015340/1–421	5 meg ±20% 2 W var
R29	02032040/RC20BF184K	180,000 ±10% 1/2 W
R30	02034990/RC30BF683K	68,000 ±10% 1 W
R31	02031890/RC20BF103K	10,000 ±10% 1/2 W
R32	02032210/RC20BF475K	4.7 meg ±10% 1/2 W
R33	02032040/RC20BF184K	180,000 ±10% 1/2 W
R34	01023900	1200 ±20% 1.5 W wire wd.

SWITCHES

S1	05000100/5–10	Toggle SPDT
S2	05000120/5–12	Toggle DPDT
S3	5B–13386	Rotary 4P7T

TRANSFORMERS

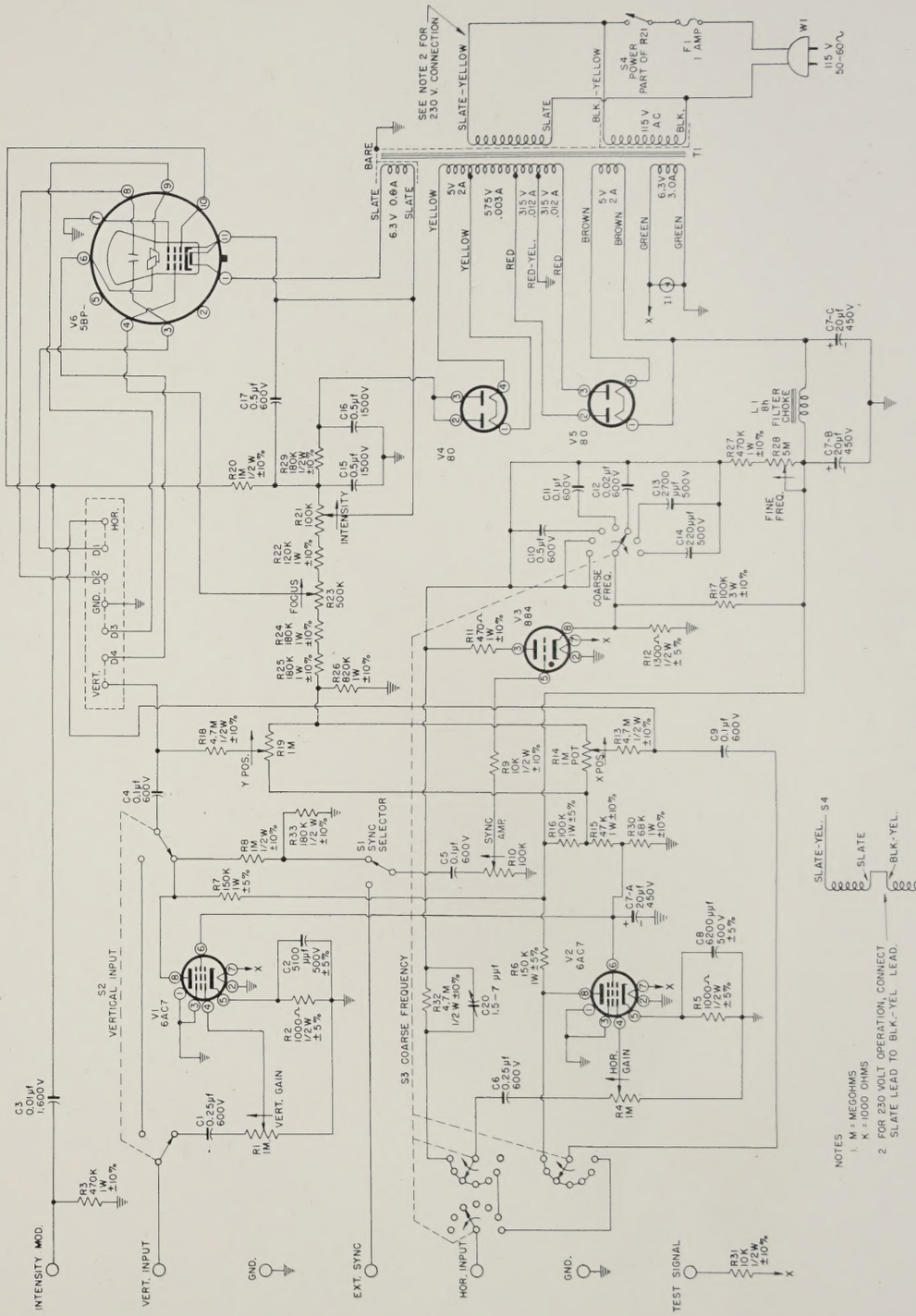
T1	20C–13382	Transformer

TUBES

V1	25000120/25–6AC7	Elec 6AC7
V2	25000120/25–6AC7	Elec 6AC7
V3	25000740/25–884	Elec 884
V4	25000720/25–80	Elec 80
V5	25000720/25–80	Elec 80
V6	25000520/25–5BP	Elec 5BP

CABLE ASSEMBLY

W1	50002980/46–108	Cable Assembly Power



SCHEMATIC OF CIRCUIT. TYPE 274-A CATHODE-RAY OSCILLOGRAPH

Ref. Dwg. D-13381
Issue 8

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